nanoSurf®

Operating Instructions

easyScan 2 STM

Version 2.1

"Nanosurf" and the Nanosurf Logo are trademarks of Nanosurf AG,
registered and/or otherwise protected in various countries.
Copyright © April 2009, Nanosurf AG, Switzerland.
Prod.Nr.: BT02090, Version 2.1, Revision 2.

Table of contents

Table of contents

CHAPTER 1: The easyScan 2 STM 12

1.1: Components of the system 13
1.1.1: Contents of the Tool Set 14

1.2: Connectors, indicators and controls 15
1.2.1: The easyScan 2 STM Scan Head 16
1.2.2: The easyScan 2 Controller 16

CHAPTER 2: Installing the easyScan 2 STM 20

2.1: Installing the hardware 20
2.1.1: Installing the easyScan 2 controller 20
2.1.2: Installing the Signal Module S 21
2.1.3: Installing the Signal Module A and its Connector Box 21
2.1.4: Installing the easyScan 2 STM Scan Head 22

2.2: Installing the easyScan 2 Software 22
2.2.1: Preparations before installing 22
2.2.2: Initiating the installation procedure 23
2.2.3: Hardware recognition 24
2.2.4: Manual installation of the USB Video Adapter driver 25

CHAPTER 3: Preparing for measurement 30

3.1: Initializing the easyScan 2 Controller 30

3.2: Preparing and installing the STM tip 30

3.3: Installing the sample 34
3.3.1: Preparing the sample 34
3.3.2: Nanosurf samples 34
3.3.3: Mounting a sample 36

CHAPTER 4: First measurements 40

4.1: Running the microscope simulation 40

4.2: Preparing the instrument 41
4.2.1: Entering values in the control panels 41

4.3: Approaching the sample to the tip 42
4.3.1: Manual coarse approach 43
4.3.2: Manual approach using the approach motor 44
4.3.3: Automatic final approach 45

4.4: Starting a measurement 46

4.5: Achieving atomic resolution 47
4.5.1: General instructions 47
4.5.2: The graphite surface 49
4.5.3: Measuring Gold 50
4.6: Storing the measurement 51
4.7: Creating a basic report 52
4.8: Further options 52

CHAPTER 5: Improving measurement quality 56
5.1: Removing interfering signals 56
5.1.1: Mechanical vibrations 56
5.1.2: Electrical interference 56
5.2: Decreasing thermal drift 57
5.3: Adjusting the measurement plane 57
5.4: Judging tip and tunneling contact quality 60

CHAPTER 6: Operating modes 66
6.1: Constant Current mode 66
6.2: Constant Height mode 66

CHAPTER 7: Finishing measurements 70
7.1: Finishing scanning 70
7.2: Turning off the instrument 70
7.3: Storing the instrument 71

CHAPTER 8: Maintenance 74
8.1: Scan Head 74
8.1.1: Protecting the sample holder against corrosion 74
8.1.2: Cleaning parts of the approach motor 74
8.2: Scan electronics 75

CHAPTER 9: Problems and solutions 78
9.1: Software and driver problems 78
9.1.1: No connection to microscope 78
9.1.2: USB Port error 78
9.1.3: Driver problems 79

9.2: STM measurement problems 81
9.2.1: Manual approach is too slow / stops sometimes 81
9.2.2: Automatic final approach is too slow / stops sometimes 81
9.2.3: Automatic final approach crashes the tip into the sample ... 82
9.2.4: Image quality suddenly deteriorates 83
9.3: Nanosurf support 84
9.3.1: Self help 84
9.3.2: Assistance 84

CHAPTER 10: STM theory 88
10.1: What is STM? 88
10.2: Scanning with the easyScan 2 STM 89

CHAPTER 11: Technical data 94
11.1: Specifications and features 94
11.1.1: The easyScan 2 Controller 94
11.1.2: The easyScan 2 STM Scan Heads 97
11.1.3: Operating modes 97
11.2: The Signal Modules 97
11.2.1: Signal Module S 98
11.2.2: Signal Module A 98
11.2.3: Using the User Inputs and Outputs 101

CHAPTER 12: The control software user interface 104
12.1: The main window 104
12.2: Operating windows 105
12.3: Measurement document windows 106
12.4: Tool bars 106
12.4.1: Arranging tool bars 106
12.5: Control panels 107
12.5.1: Arranging control panels 108
12.5.2: Storing and retrieving the workspace 108
12.5.3: Entering values in the control panels 109
12.5.4: Storing and retrieving measurement parameters 110
12.6: The User Interface dialog 110

CHAPTER 13: Hardware-related settings 114
13.1: The Operating Mode panel 114
13.1.1: STM mode 115
13.1.2: Static Force mode 116
13.1.3: The User Signal Editor 117
13.1.4: Dynamic Force mode 118
13.1.5: Phase Contrast mode 120
13.1.6: Force Modulation mode 120
13.1.7: Spreading Resistance mode 120
13.1.8: The Vibration Frequency Determination dialog 121
13.1.9: The Vibration Frequency Search Parameters dialog 124
13.2: The Z-Controller panel 125
13.3: Cantilever types configuration 128
13.3.1: The Cantilever Browser dialog 128
13.3.2: The Cantilever Editor dialog 130
13.4: Scan Head configuration 132
13.4.1: The Scan Head Selector dialog 132
13.4.2: The Scan Head Calibration Editor dialog 133
13.4.3: The Scan Axis Correction dialog 135
13.5: The Controller Configuration dialog 136
13.6: The Signal Module Configuration dialog 137
13.7: The Edit Access Codes dialog 139
13.8: Simulate Microscope 139
13.9: The About dialog 140
CHAPTER 14: Positioning 142
14.1: The Approach panel 142
14.2: The Video panel 145
CHAPTER 15: Imaging 148
15.1: The Imaging bar 148
15.2: The Imaging panel 151
CHAPTER 16: Spectroscopy 158
16.1: The Spectroscopy bar 159
16.2: The Spectroscopy panel 160

CHAPTER 17: Lithography 166
17.1: Performing lithography 167
17.2: The Lithography bar 169
17.2.1: The Vector Graphic Import dialog 171
17.2.2: The Pixel Graphic Import dialog 173
17.3: The Lithography panel 176
17.3.1: The Layer Editor dialog 178
17.3.2: The Object Editor dialog 181
17.4: The Lithography Preview panel 182
17.5: The Lithography Topography map view 183
CHAPTER 18: Viewing measurements 186
18.1: Charts 186
18.1.1: Storing and retrieving the chart arrangement 187
18.2: The Chart bar 187
18.2.1: The Chart Properties dialog 190
18.2.2: Changing the appearance of the 3D view 191
18.2.3: The Color Palette dialog 192
18.3: The Data Info panel 193
CHAPTER 19: Quick evaluation tools 196
19.1: The Tool Results panel 196
19.2: The Tools bar 199
CHAPTER 20: Storing and processing data 212
20.1: Storing and printing measurements 212
20.2: Creating a report 214
20.2.1: The Report Menu 215
20.2.2: The Report Generator Configuration dialog 216
CHAPTER 21: Automating measurement tasks 218
21.1: The Script Menu 218
21.2: The Script Editor 219
21.3: The Script Configuration Dialog 220
Quick reference 222

About this Manual

This manual is divided into two parts: The first part provides instructions on how to set up and use your Nanosurf easyScan 2 STM system. The second part is a reference for the software that comes with the easyScan 2 STM system. It applies to Nanosurf easyScan 2 software version 2.1. If you are using newer software versions, download the latest manual from the Nanosurf support pages, or refer to the "What's new in this version.pdf" file that is installed in the Manuals subdirectory of the directory where the easyScan 2 software is installed.

The first part of the manual starts with *Chapter 1: The easyScan 2 STM* (page 12), which provides an introduction to the easyScan 2 STM system, and with *Chapter 2: Installing the easyScan 2 STM* (page 19), which should be read when installing your system. *Chapter 3: Preparing for measurement* (page 29) and *Chapter 4: First measurements* (page 39) should be read by all users, because they contain useful instructions for everyday measurements. The other chapters provide more information for advanced or interested users.

The second part of the manual can be used as a reference for the Nanosurf easyScan 2 software that controls the STM. It starts with *Chapter 12: The control software user interface* (page 103) and ends with *Chapter 21: Automating measurement tasks* (page 218). This part describes the functions of all buttons, inputs, dialogs, and control panels of the easyScan 2 software. The final chapter of this manual, *Quick reference* (page 222), contains an index to the software reference part of the manual for quick retrieval of the relevant information locations.

For more information on the scripting interface of the software packages, refer to the online help file *easyScan 2 Script Programmers Manual* that is installed together with the easyScan 2 software.

For more information on the optional Nanosurf Report software, refer to the online help included with the Nanosurf Report software.

CHAPTER 1:

The easyScan 2 STM

Chapter 1: The easyScan 2 STM

The Nanosurf easyScan 2 STM system was designed to allow people without training as a physicist to do experiments in the world of atoms. Its design is compact, simple and comfortable to operate. With the easyScan 2 STM, it is possible to do all STM experiments that can be carried out in air. The tip–sample approach stage allows simple handling of samples and tips, while at the same time providing maximum stability of the tip–sample distance. All functions can be carried out using a computer and the easyScan 2 software.

The easyScan 2 STM system is a modular scanning probe system that can be upgraded to obtain more measurement capabilities. The main parts of the basic system are the easyScan 2 STM Scan Head, the Vibration Isolation Platform, the easyScan 2 Controller, and the easyScan 2 software.

The content of the system and the function of its major components are described in this chapter. Detailed technical specifications and features can be found in *Chapter 11: Technical data* (page 94).

Several other Nanosurf products can be used in conjunction with the easyScan 2 STM:

- STM Scan Head: makes atomic scale measurements. Refer to the *easyScan 2 STM Operating Instructions* for more details.
- Signal Modules: allow monitoring signals (Module S) and creating custom operating modes (Module A). Refer to *Section 11.2: The Signal Modules* (page 97) for more details.
- Nanosurf Report: software for simple automatic evaluation and reporting of SPM measurements.
- Nanosurf Analysis: software for detailed analysis of SPM measurements.
- Scripting Interface: software for automating measurements. Refer to *Chapter 21: Automating measurement tasks* (page 217) and the *Programmer's Manual* for more details.
- Lithography Option: software for professional lithography applications. Refer to *Chapter 17: Lithography* (page 166) for more information.

- The TS-150 Active Vibration Isolation Table: an active vibration isolation solution.

1.1: Components of the system

This section describes the parts that may be delivered with an easyScan 2 STM system. The contents of delivery can vary from system to system, depending on which parts were ordered. To find out which parts are included in your system, refer to the delivery note shipped with your system. Some of the modules listed in the delivery note are built into the Controller. Their presence is indicated by the status lights on the top surface of the Controller when it is turned on (see *Section 1.2.2: The easyScan 2 Controller* (page 16)).



Figure 1-1: Components. The easyScan 2 STM system

1. easyScan 2 Controller with built in optional Signal Module A or Signal Module S electronics, and other modules used for AFM operation.
2. easyScan 2 STM Scan Head.
3. Magnifying cover with 10× magnifier.

4. USB cable.
5. Mains cable.
6. STM Tool set (option). The contents of the STM Tool set are described in the next section.
7. The easyScan 2 Installation CD: Contains software, calibration files, and PDF files of all manuals (not shown).
8. A calibration certificate for each easyScan 2 STM Scan Head (not shown).
9. This easyScan 2 STM Operating Instructions manual (not shown).
10. Vibration isolation platform (option).
11. Break-out cable (comes with Signal Module S).
12. Connector box (comes with Signal Module A).
13. Signal Module cables (2×) (come with Signal Module A).
14. Scripting Interface certificate of purchase with Activation key printed on it (comes with Scripting Interface, not shown).
15. Lithography Option certificate of purchase with Activation key printed on it (comes with the Lithography Option, not shown).
16. Instrument Case (not shown).

The package may also contain easyScan 2 AFM head(s) and modules for the AFM, which are described in the *easyScan 2 AFM Operating Instructions.*

Please keep the original packaging material (at least until the end of the warranty period), so that it may be used for transport at a later date, if necessary. For information on how to store, transport, or send in the instrument for repairs, see *Section 7.3: Storing the instrument* (page 71).

1.1.1: Contents of the Tool Set

The content of the Tool set depends on the modules and options included in your order. It may contain any of the following items:

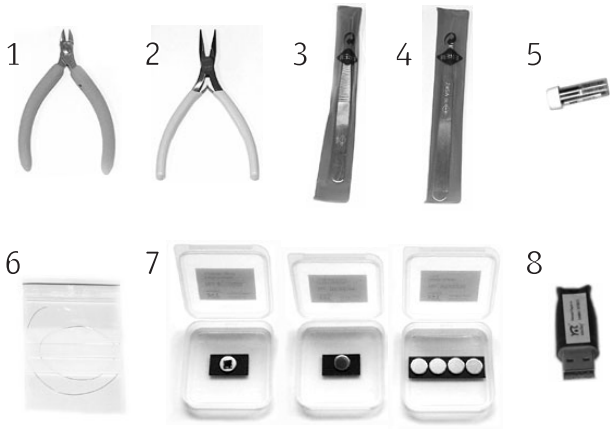


Figure 1-2: Contents of the Tool set

1. Wire cutters.
2. Flat Nose Pliers.
3. Pointed tweezers (00D SA).
4. Rounded tweezers (2A SA-SL).
5. Sample holder (comes as an option with the AFM
6. Pt/Ir wire: 0.25mm/30cm for making STM tips (option).
7. STM Basic Sample Kit (option) with HOPG (graphite), gold thin film and four spare sample supports.
8. USB dongle for Nanosurf Report or Nanosurf Analysis software (option).

1.2: Connectors, indicators and controls

Use this section to find the location of the parts of the easyScan 2 STM that are referred to in this manual.

1.2.1: The easyScan 2 STM Scan Head

Two types of easyScan 2 STM Scan Heads exist, that have different approach stages. In type one stages, the Sample Holder slides on guide bars. In type two stages, the Sample Holder slides on a point support (see *Figure 1-3: Parts of the Scan Head*).

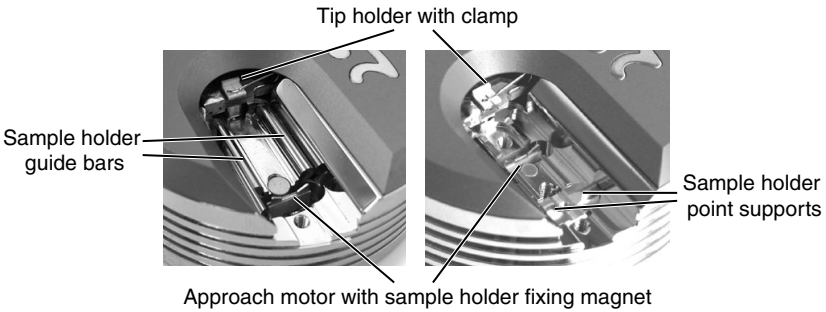


Figure 1-3: Parts of the Scan Head. (left) Type one Scan Head, (right) Type two Scan Head.

1.2.2: The easyScan 2 Controller

Status lights

All status lights on top of the controller will light up for one second when the power is turned on.

The Probe Status light

Indicates the status of the Z-feedback loop. The Probe Status light can be in any of the following states:

– **red** The scanner is in its upper limit position. This occurs when the tip–sample interaction is stronger than the set point for some time. There is danger of damaging the tip due to an interaction that is too strong.

– **orange/yellow** The scanner is in its lower limit position. This occurs when the tip–sample interaction is weaker than the set point for some time. The tip is probably not in contact with the sample surface.

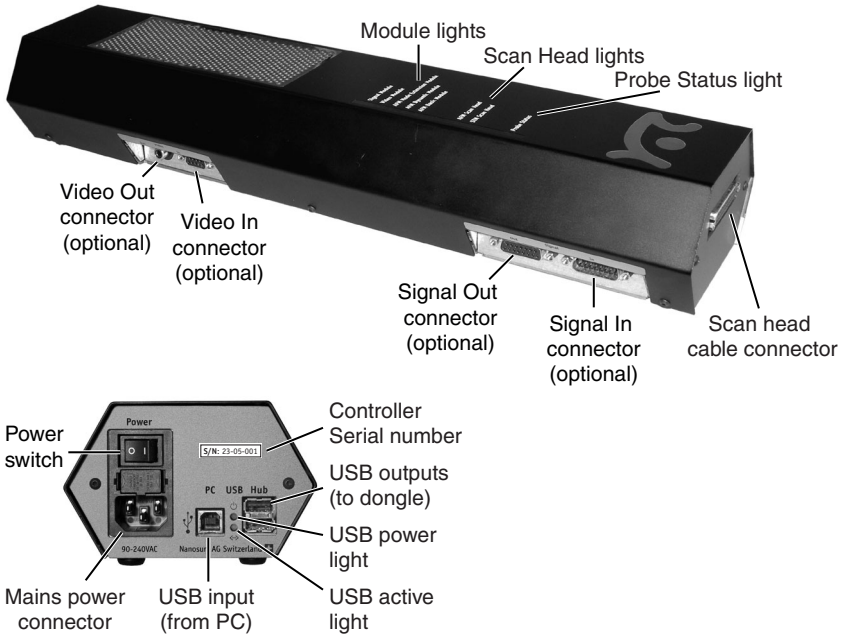


Figure 1-4: The easyScan 2 controller

– **green** The scanner is not in a limit position, and the feedback loop can measure the sample surface.

– **blinking green** The feedback loop has been turned off in the software.

The Scan Head lights

Indicate the Scan Head type that is connected to the instrument. The Scan Head lights blink when no Scan Head can be detected, or when the controller has not been initialized yet.

The Module lights

Indicate the modules that are built in into the controller. The module lights blink when the controller has not been initialized yet. During initialization, the module lights are turned on one after the other.

CHAPTER 2:

Installing the easyScan 2 STM

CHAPTER 2: Installing the easyScan 2 STM

The following sections describe the installation of the easyScan 2 STM.

IMPORTANT

To allow measurements with atomic resolution to be made, the following precautions must be taken to keep the equipment dust- and grease-free:

- Never let your fingers touch either the wire for tips (*Figure 1-2: Contents of the Tool set* (page 15), item 6), the sample (*Figure 1-2: Contents of the Tool set* (page 15), item 7) nor the parts of the STM scan head indicated in *Figure 1-3: Parts of the Scan Head* (page 16).
- Only touch the Sample Holder (*Figure 1-2: Contents of the Tool set* (page 15), item 5) at the black plastic end.

2.1: Installing the hardware

IMPORTANT

- Make sure that the mains power connection is protected against excess voltage surges.
- Place the instrument on a stable support in a location that has a low level of building vibrations, acoustic noise, electrical fields, and air currents.

2.1.1: Installing the easyScan 2 controller

❶ Connect the USB Cable (*Figure 1-1: Components* (page 13), item 4) to the easyScan 2 Controller, but do not connect it to the computer yet.

If you have inadvertently done this anyway, Windows will attempt to install drivers for the newly found hardware. When this happens:

Ⓐ Do NOT break off the installation!

Ⓑ Insert the Software Installation CD (if the Software Installation program should start, choose "Exit" first) and follow the steps described for the USB Video Adapter in *Section 2.2.4: Manual installation of the USB Video Adapter driver* (page 25), to let Windows search for the necessary drivers on this CD.

C When this process has finished, disconnect the USB cable from the computer, finish the remaining steps below, and then go through the Software Installation procedure as described in *Section 2.2: Installing the easyScan 2 Software* (page 22).

❷ Connect the easyScan 2 Controller to the mains power using the Mains Cable (*Figure 1-1: Components* (page 13), item 5), but do not turn on the controller yet.



Figure 2-1: Measurement setup. Complete easyScan 2 STM system.

2.1.2: Installing the Signal Module S

To install the Signal Module S:

➔ Connect the Break-out cable (*Figure 1-1: Components* (page 13), item 11) to the Signal Out connector on the Controller (*Figure 1-4: The easyScan 2 controller* (page 17)).

In case of an upgrade, the Controller must be sent in to your local Nanosurf distributor for installing the Signal Module S electronics inside the Controller.

2.1.3: Installing the Signal Module A and its Connector Box

To install the Signal Module A:

❶ Connect one Signal Module cable (*Figure 1-1: Components* (page 13), item 13) to the Signal Out connector on the Controller and to the Output connector on the Signal Module A.

❷ Connect the other Signal Module cable to the Signal In connector on the Controller and to the Input connector on the Signal Module A.

In case of an upgrade, the Controller must be sent in to your local Nanosurf distributor for installing the Signal Module A electronics in the Controller.

2.1.4: Installing the easyScan 2 STM Scan Head

To mount the Scan Head

❶ Attach the Scan Head cable to the easyScan 2 Controller.

❷ Place the Scan Head onto the vibration isolation platform (*Figure 1-1: Components* (page 13), item 10).

❸ Fix the scan head cable under the strain relief clip on the platform.

If the vibration isolation of your table is insufficient for your measurement purposes, use an active vibration isolation table such as the TS-150. Refer to the respective manuals for installation instructions.

2.2: Installing the easyScan 2 Software

2.2.1: Preparations before installing

Before installation, the following steps need to be performed:

❶ Make sure the computer to be used meets the minimal computer requirements, as described in *Chapter 11: Technical data* under *Computer requirements* (page 95).

❷ When the easyScan 2 controller is connected to the computer via the USB cable, disconnect it by unplugging the USB cable from the computer.

The easyScan 2 controller should only be connected to the computer when the software and driver installation is complete.

❸ If you are running Windows Vista, disconnect from the internet.

This step is necessary to prohibit Windows Vista from obtaining an improper driver from the Internet.

❹ Turn on the computer and start Windows.

5. Log on to your computer with Administrator privileges.

IMPORTANT

Do not run any other programs while installing the easyScan 2 software.

2.2.2: Initiating the installation procedure

To initiate the installation procedure:

1. Insert the easyScan 2 Installation CD into the CD drive of the computer.

   In most cases, the Autorun CD Menu program will open automatically. Depending on your Autoplay settings, however, it is also possible that the Autoplay window opens, or that nothing happens at all. In these cases:

   - Click "Run CD_Start.exe" in the Autoplay window, or manually open the easyScan 2 Installation CD and start the program "CD_Start.exe".

IMPORTANT

The easyScan 2 Installation CD contains calibration information (.hed files) specific to your instrument! Therefore, always store (a backup copy of) the CD delivered with the instrument in a safe place.

2. Click the "Install easyScan 2 Software" button.

   The CD Menu program now launches the software setup program, which will start installation of all components required to run the Nanosurf easyScan 2 software.

   In Windows Vista, the User Account Control (UAC) dialog may pop up after clicking the "Install easyScan 2 Software" button, displaying the text "An unidentified program wants access to your computer". If the name of the program being displayed is "Setup.exe":

   - Click the "Allow" button.

After the software setup program has started:

1. Click "Next" in the "Welcome", "Select Destination Folder", and "Select Start Menu Folder" windows that sequentially appear, accepting the default choices in all dialogs.

❷ When the "Ready to install" window appears, click on the "Install" button. The setup program now performs its tasks without any further user interaction. Depending on the configuration of your computer, a reboot may be required at the end of the software installation process. If this is the case, the setup program will inform you of this, and will provide you with the opportunity to do so.

This completes the software installation procedure. Proceed with *Section 2.2.3: Hardware recognition* to complete the setup process.

2.2.3: Hardware recognition

To initiate the automatic hardware recognition process for the devices present in your controller:

❶ Log on to your computer with Administrator privileges.

❷ Power on the controller.

❸ Connect the controller to the computer with the supplied USB cable (*Figure 1-1: Components* (page 13), item 4).

A popup balloon appears in the Windows notification area, stating that new hardware devices have been found and drivers are being installed. Depending on the configuration of your controller and computer, any of the following devices may show up during driver installation:

- Standard USB-Hub
- USB-to-Serial interface
- Composite Device
- USB Serial Port
- USB Device (Video Module)
- USB 2821 Device
- USB EMP Audio Device

On some computers, the detection process can take quite some time (20 seconds or more). Please be patient. After successful automatic installation,

the popup balloon indicates that the installation has finished and that the devices are now ready for use.

With some older controllers, manual installation of the Video Adapter driver will be required. This is indicated by the appearance of the "Found new Hardware" window during hardware recognition. The procedure to install the driver manually differs slightly between Windows 2000/XP and Windows Vista, and is detailed in *Section 2.2.4: Manual installation of the USB Video Adapter driver*. On controllers where manual installation of the USB Video Adapter driver is required, *Hardware recognition* and *Manual installation of the USB Video Adapter driver* should be repeated for each USB port in the computer. It is recommended to do this now while you are logged on with Administrator privileges.

This completes the hardware recognition process and the entire setup process. If you wish to use the Lithography features of the easyScan 2 software and want to design your own vector graphics for import into the lithography module, you can opt to install the LayoutEditor software by clicking the "Install CAD Program" button in the CD Menu program. This will launch the LayoutEditor installation program, which will guide you through the CAD program setup. Otherwise, you may exit now by clicking the "Exit" button.

2.2.4: Manual installation of the USB Video Adapter driver

If required for your controller, follow the operating-system-specific instructions below for manual installation of the Video Adapter driver. If *Hardware recognition* was completed automatically, this section can be skipped.

Windows Vista

To manually install the USB Video Adapter driver:

❶ In the "Found New Hardware" dialog for an "Unknown Device", click the "Locate and install driver software (recommended)" button.

The User Account Control (UAC) dialog may pop up after pressing this button, displaying the text "Windows needs your permission to continue" for a "Device driver software installation". If this is the case:

➲ Click the "Continue" button.

❷ In the next dialog, which states "Windows couldn't find driver software for your device", click the "Browse my computer for driver software (advanced)" button.

❸ In the next dialog, "Browse" to your CD drive (usually D:) or manually type "D:\" (or the corresponding drive letter) into the Path field. Make sure "include subfolders" is checked. Then click the "Next" button.

Windows begins searching the specified path, and — since an unsigned driver is found — a Windows Security window opens, stating that "Windows can't verify the publisher of this driver software"

❹ In the Windows Security window, click the "Install this driver software anyway" button.

The Found New Hardware window now displays a "USB Video Adapter" and driver installation will take place.

❺ When Windows has finished installing the Video driver software, click the "Close" button.

Windows 2000/XP

To manually install the USB Video Adapter driver:

❶ When the "Found New Hardware" dialog displays the text "Can Windows connect to Windows Update to search for software?", select "No, not this time" and click the "Next" button .

❷ In the next dialog, select "Install automatically (recommended)" and click the "Next" button.

Windows now begins searching for the appropriate driver, and — since an unsigned driver is found — a Warning window opens, stating that "The software that you are trying to install for this hardware: USB Video Adapter has not passed Windows Logo testing for compatibility with Windows XP".

❸ In the Warning window, click the "Continue anyway" button.

Under some circumstances a "Files Needed" window may now pop up. If this is the case:

➔ "Browse" to the Installation CD's "DriverPAL" folder and click the "OK" button.

4. When Windows has finished installing the Video driver software, click the "Finish" button.

CHAPTER 3:

Preparing for measurement

CHAPTER 3: Preparing for measurement

Once the system has been set up (see *Chapter 2: Installing the easyScan 2 STM* (page 19)), the instrument and the sample have to be prepared for measurement. The preparation consists of three steps: *Initializing the easyScan 2 Controller*, *Preparing and installing the STM tip*, and *Installing the sample*.

3.1: Initializing the easyScan 2 Controller

To initialize the easyScan 2 controller:

1. Make sure that the easyScan 2 controller is connected to the mains power and to the USB port of the control computer.
2. Turn on the power of the easyScan 2 controller.

   First all status lights on top of the controller briefly light up. Then the Scan Head lights and the lights of the detected modules will start blinking, and all other status lights turn off.
3. Start the easyScan 2 software on the control computer.

   The main program window appears, and all status lights are turned off. Now a Message "Controller Startup in progress" is displayed on the computer screen, and the module lights are turned on one after the other. When initialization is completed, a Message "Starting System" is briefly displayed on the computer screen, and the Probe Status light, the Scan Head status light of the detected scan head, and the Module lights of the detected modules will light up. If no scan head is detected, both Scan Head Status lights blink.

3.2: Preparing and installing the STM tip

The STM tip can be prepared and installed by yourself. This is the most difficult part of your preparations. It usually needs patience and some practise to get the first good tip. Only an accurately cut tip enables optimal measurements. Therefore, cutting and installing should be carried out with great care. On delivery, the tip with which the STM was calibrated in the factory is installed in the head. This tip should give atomic resolution, so you may wish to try to use this tip before preparing your own.

Before cutting the tip:

1. Clean the cutting part of the wire cutters (*Figure 1-2: Contents of the Tool set* (page 15), item 1), the Flat nose pliers (item 2) and the pointed tweezers (item 3) with ethanol.

   Only touch the Pt/Ir wire (item 6) with these tools.

2. Remove the old tip from the instrument using the pointed tweezers.

   If the tip wire is still long enough, you may try to cut the same wire again, otherwise cut the Pt/Ir wire.

To prepare the tip:

1. Hold the end of the wire firmly with the pliers.

2. Holding the wire with the pliers, move the cutters at a length of approximately 4 mm, as obliquely as possible (*Figure 3-1: Cutting the STM tip*).

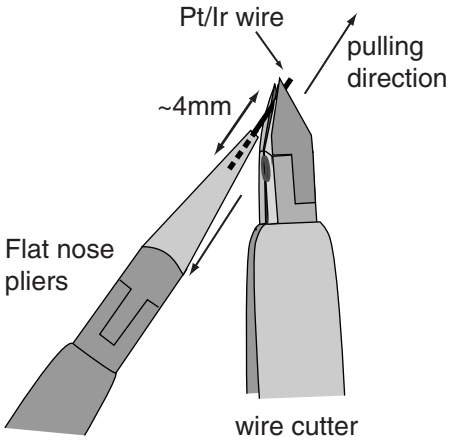


Figure 3-1: Cutting the STM tip

3. Close the cutters until you can feel the wire, but do not cut the wire.

4. Pull in the direction shown in *Figure 3-1: Cutting the STM tip*. The tip needs to be torn off rather than cleanly cut through, in order to obtain the required tip sharpness.

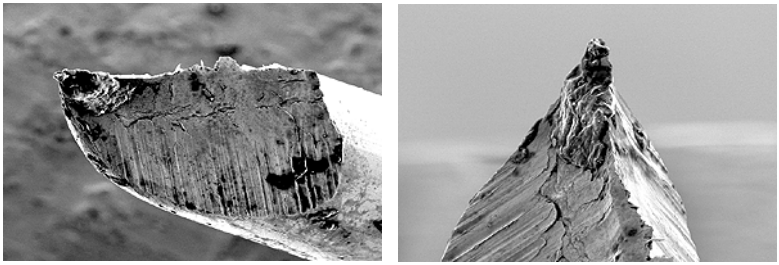


Figure 3-2: STM tip. Scanning Electron Microscope images of an STM tip

5. Use the pointed tweezers to hold the tip wire with just behind the tip.
6. Release the flat pliers.

IMPORTANT

- Never touch the end of the tip with anything.
- Ensure that the tip wire is straight.
- Do not twist the tip clamp in any way, nor lift it too high.

The procedure for mounting the tip under the tip clamp depends on the type of clamp on your scan head (single or double clamp).

Single clamp

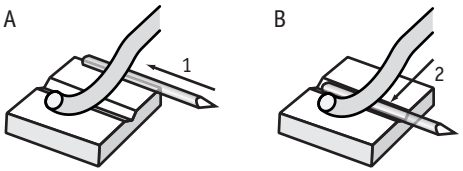


Figure 3-3: Mounting the tip under the single clamp

In case of a single clamp scan head, proceed as follows:

1. Put the tip wire on the tip holder parallel to the groove in the tip holder, so that it crosses below the tip clamp (*Figure 3-3: Mounting the tip under the single clamp*, A).

❷ Move the tip wire sideways until it is in the groove in the tip holder (*Figure 3-3: Mounting the tip under the single clamp*, B).

The freshly cut tip should be securely held under the clamp and extend about 2–3 mm beyond the tip holder.

The tip is now installed.

Double clamp

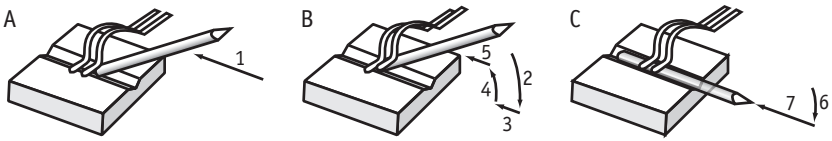


Figure 3-4: Mounting the tip under the double clamp

Always use the following procedure for mounting the tip under the double clamp, as using a different procedure may cause a gradual deterioration of the measurement quality due to loosening of the clamp:

❶ Hold the tip wire at a slight angle, and move it along the groove against the first clamp, so that the end of the wire is under the clamp (*Figure 3-4: Mounting the tip under the double clamp*, A).

❷ Lower the wire so that it lifts the first clamp (*Figure 3-4: Mounting the tip under the double clamp*, B).

❸ Push the wire in, until it touches the second clamp.

❹ Lift the wire.

❺ Push the end of the wire below the second clamp.

❻ Lower the wire so that it lifts the second clamp (*Figure 3-4: Mounting the tip under the double clamp*, C).

❼ Push the wire under the second clamp.

The freshly cut tip should be securely held under the clamp and extend about 2–3 mm beyond the tip holder.

The tip is now installed.

3.3: Installing the sample

3.3.1: Preparing the sample

IMPORTANT

Never touch the sample surface once it is prepared.

The STM can be used to examine electrically conductive materials. In practice, however, the choice of material is more limited, because the surface of the sample must be totally clean and mirror-like to obtain useful results, and it must be in a non-oxidized state to be conductive. Because of this, some samples need special preparation.

3.3.2: Nanosurf samples

Nanosurf delivers various optional samples, which are usually packed in the STM Tool Set. These samples are briefly described here. Further samples are available in the STM Extended Sample Kit, which contains its own sample description.

All samples should be stored in their respective box. This way, it should not be necessary to clean them. Cleaning of the samples is generally not advisable (unless indicated below), because their surfaces are often rather delicate.

Gold thin film

Cleaning the sample is neither possible nor necessary. Never touch the sample with your fingers or put it upside down anywhere, this will only make it unusable faster.

Graphite (HOPG) on sample support

This sample can be used for STM as well as AFM measurements. In STM measurements, atomic resolution can be obtained on this sample.

Sample specifications:

Size: 5 mm × 5 mm

Material: Highly Oriented Pyrolytic Graphite (HOPG)

Sample support: Magnetic Steel disc, galvanized with Nickel.

The surface of the graphite sample can be cleaned when it is very dirty or uneven. Due to the layered structure of graphite this can easily be done using a piece of adhesive tape (*Figure 3-5: Cleaving graphite*):

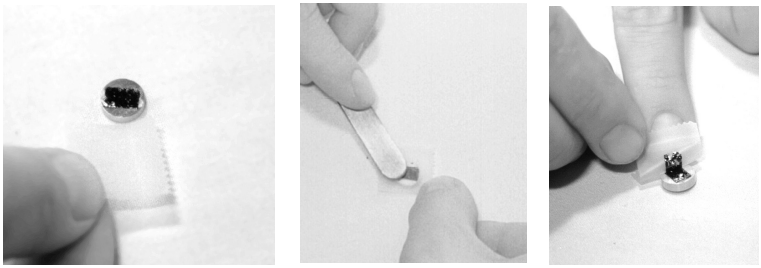


Figure 3-5: Cleaving graphite

1. Put the sample on the table using a pair of tweezers.
2. Stick a piece of adhesive tape gently to the graphite and then pull it off again. The topmost layer of the sample should stick to the tape.
3. Remove any loose flakes with the tweezers.

The graphite sample is now ready for use and should not be touched anymore.

Other samples

You can mount other samples on the spare disc shaped sample supports (*Figure 1-2: Contents of the Tool set* (page 15), item 7). The supports are made of a magnetic steel that is galvanically coated with nickel. Use conducting glue to attach the sample to the sample support. Contact your Nanosurf distributor if you have difficulties obtaining such a glue.

3.3.3: Mounting a sample

To mount a sample onto the Sample Holder:

❶ Unpack the Sample Holder (*Figure 1-2: Contents of the Tool set* (page 15), item 5) touching only its black plastic handle.

IMPORTANT

Always store the Sample Holder in its package, in order to prevent corrosion (see *Chapter 8: Maintenance* (page 74)).

❷ Put the prepared sample onto the magnetic end of the Sample Holder using a pair of tweezers (*Figure 3-6: Putting the sample on the Sample Holder*).

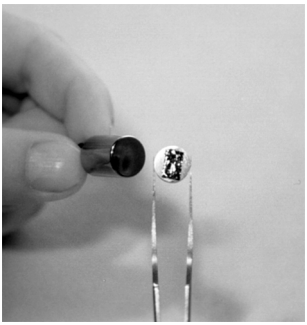


Figure 3-6: Putting the sample on the Sample Holder

❸ Place the Sample Holder carefully in the scan head so that it doesn't touch the tip, and in such a way that the sample is not pulled from the Sample Holder by the magnet that holds the Sample Holder in place (*Figure 3-7: Placing the Sample Holder in the Scan Head*).

❹ Put the Sample Holder down on to the Sample Holder guide bars first and release it gently on to the approach motor's support.



Figure 3-7: Placing the Sample Holder in the Scan Head

CHAPTER 4:

First measurements

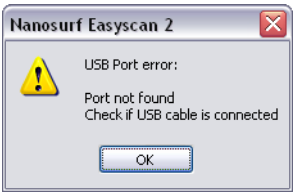
CHAPTER 4: First measurements

In this chapter, step-by-step instructions are given to operate the microscope and to perform simple measurements. More detailed explanations of the software and of the system can be found elsewhere in this manual.

4.1: Running the microscope simulation

The easyScan 2 software can be started without having the microscope connected to your computer in order to explore the easyScan 2 system (measurements and software) without danger of damaging the instrument or the STM tip. In simulation mode, most functions of the real microscope are emulated. The sample is replaced by a mathematical description of a surface.

When the easyScan 2 software is started without a microscope connected to your computer, the following dialog appears:



- Click “OK”.
  The status bar will now display the text “Simulation”.

You can also switch to the simulation mode with the microscope connected:

- Select the menu entry “Options” >> “Simulate Microscope”.
  A check mark will now be displayed in front of the menu entry.

To exit the Microscope simulation mode:

- Select the menu entry “Options” >> “Simulate Microscope” again.
  The check mark in front of the menu entry is now removed, and the status bar will now display the text “Online”.

4.2: Preparing the instrument

Prepare the instrument as follows (see *Chapter 3: Preparing for measurement* (page 29) for more detailed instructions):

1. Prepare and install a Pt/Ir tip.
2. Install the HOPG sample.

To make sure that the configuration is correct, do the following:

1. Open the User interface dialog via the menu “Options” >> “Config User Interface...”.
2. Select the “Easy level” user interface mode.
3. Open the menu item “File” >> “Parameters” >> “Load...”, and load the file “Default_EZ2-STM.par” from the directory that holds the default easyScan 2 configurations.

   Usually this is “C:\Program Files\Nanosurf\Nansurf easyScan 2 software\Config”.

4.2.1: Entering values in the control panels

To change a parameter in any panel:

1. Activate the parameter by clicking it with the mouse pointer, or by selecting it with the “Tab” key.
2. In case of a drop-down menu selection list (e.g.: 

), change the selection using the mouse, or the up and down arrows on the keyboard. In case of a numerical value, use one of the following methods:

   - Use the up and down arrow keys on the keyboard to increase or decrease its value. The new value is automatically used after one second.
   - Click the arrow buttons  next to the parameter’s value with the mouse pointer. The new value is automatically used after one second.
   - Enter the new value using the keyboard. The entered value is applied upon pressing the “Enter” or “Return” key, or by activating another input. The

entered value is discarded upon pressing the "Esc" key. The unit prefix can be changed by typing one of the following keyboard keys:

f	= femto	space bar	= no prefix
p	= pico	k	= kilo
n	= nano	M (shift-m)	= mega
u	= micro	G (shift-g)	= giga
m	= milli	T (shift-t)	= tera

Examples: if the basic unit is Volts, type "m" to change to millivolts, type the space bar for volts, type "u" for microvolts.

Sometimes the program will change an entered parameter value to a slightly different value. This happens when the desired value is outside the digitization range of the easyScan 2 Controller, for example due to resolution or timing limits. In such cases, the desired value is automatically changed to the nearest possible value.

4.3: Approaching the sample to the tip

To start measuring, the sample must be very close to the tip to enable a tunneling current to flow. Approaching the sample without touching the tip is a delicate operation carried out in three steps: *Manual coarse approach*, *Manual approach using the approach motor*, and the *Automatic final approach*. The color of the Status light on the controller shows the current status of the approach:

– **orange/yellow** Normal state during approach: the Z-scanner is fully extended toward the sample.

– **red** The approach has gone too far: the tip was driven into the sample, and the Z-scanner is fully retracted from the sample. In this case, the tip is probably damaged and you will have to prepare and install a new tip again.

– **green** The approach has finished successfully: the Z-scanner is within the measuring range.

To prepare for the approach process:

➊ Click  in the Navigator.
The positioning window now opens.

❸ in the Approach panel to bring the approach motor on the front-most leveling screw of the FlexAFM scan head in its upper position.

This will ensure that the maximum motorized approach range is available during automatic final approach.

During the approach steps described in the following sections, use the side view of the cantilever to judge the distance between tip and the sample surface:

- Click Side view in the Video panel of the Positioning window.
- If the FlexAFM Video Module is installed, click Side view in the Video panel of the Positioning window.

  If you do not have the Video Module, use the side view lens of the scan head to observe the sample instead.

Even if you do not have the Video Module, you can still use the Top and Side view switches to quickly change the illumination to a predetermined level.

4.3.1: Manual coarse approach

In this step, the sample surface is brought close enough to the tip by hand to allow further motorized approach afterwards.

To perform a manual coarse approach:

❶ Push the sample holder carefully to within 1 mm distance of the tip.

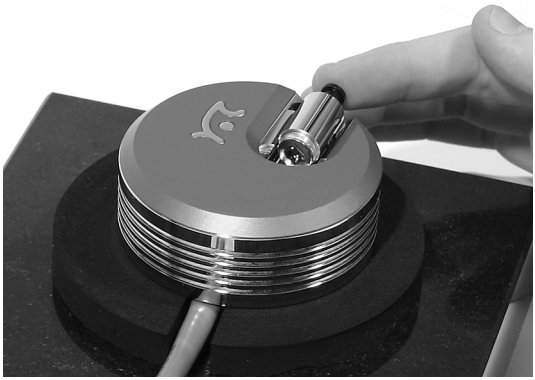


Figure 4-1: Manual Coarse approach

❷ If the tip is pointing toward a rough area of the sample, try turning the sample holder around its axis so that the tip points towards a flat, mirror-like area of the sample.

❸ Put the magnifying cover (*Figure 1-1: Components* (page 13), item 3) over the scan head without touching the sample holder.

❹ Place the magnifier in such a way that you can see the mirror image of the tip in the sample.

The cover reduces air flow around the scan head and reduces thermal drift in measurements at atomic scale.

4.3.2: Manual approach using the approach motor

In this step, the sample surface is brought as close to the tip as possible, without touching it. The closer the two are together, the less time the automatic final approach takes.

❶ Watch the distance between tip and sample with help of the magnifier.

❷ Click Advance in the Approach Panel to move the sample to within a fraction of a millimeter of tip.

You should only just be able to see the gap between the tip and its mirror image (*Figure 4-2: tip–sample position*). The smallest visible gap depends on the observation angle of the magnifier and the illumination of the sample.

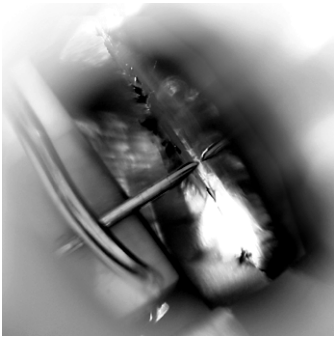


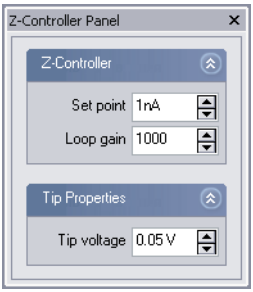
Figure 4-2: tip–sample position. Position at the end of the Manual approach with the approach motor.

❸ If you cannot see the motor moving, clean the sample holder guide bars and the surfaces of the approach motor following the procedure described in *Chapter 8: Maintenance* (page 74).

4.3.3: Automatic final approach

In this last step, the sample automatically approaches the tip until a given set point is reached. First check that the set point and the feedback speed are set properly. To do this:

❶ Click  in the Navigator to open the Z-Controller Panel:



❷ Set “Set point” (tunneling current) to 1.00 nA.

❸ Set “Loop gain” (the speed of the feedback loop) to 2000 for normal heads, or to 400 for LC heads.

❹ Set “Tip voltage” (tip–sample-voltage) to 50 mV.

Now that the setpoint and feedback settings are correct, the automatic final approach can be started:

❶ Switch to the “Positioning” window by clicking  in the Navigator.

❷ Click Approach in the Approach panel of the Positioning window.
The sample holder is now moved towards the tip by the approach motor. After each step, the Z-scanner is fully retracted from the sample, and released to move towards the sample. The approach is finished if the current determined by Set point is detected before reaching the maximum extension of the Z-scanner, otherwise the approach motor will continue with the next

step. Due to the motion of the Z-scanner, the Probe Status light will blink red–green–orange/yellow in cycles (see *The Probe Status light* (page 16)). When the approach has finished successfully, the probe status light changes from a blinking state to a constant green, and the message box "Approach done" appears.

❸ Click the "OK" button.

If the status light changes to red instead of green, or if the approach has not finished after 10–20 seconds, try to decrease the tip–sample distance a little more using manual operation of the approach motor.

If the automatic final approach never works, refer to *Chapter 9: STM measurement problems* (page 81) for the next steps to take.

4.4: Starting a measurement

Now that the tunneling current defined by Set point is flowing between tip and sample you can start measuring. To start and view the measurement:

➍ Click  to open the Imaging window.

By default, the instrument is set to automatically start measuring after the automatic approach. If the preparation of tip and sample and the approach were successful, images of the measurement will show a more or less straight line in the Line graph (*Figure 4-3: Starting image*, left) and a plane in the Color map. Watch the displays for a while until the Color map image has been drawn about three times.

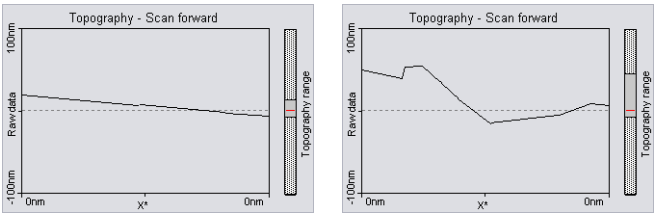


Figure 4-3: Starting image. (left) a good Line graph, (right) a "nervous" Line graph.

A "nervous" line in the Line graph indicates a bad tunneling contact (*Figure 4-3: Starting image*, right). Usually this is caused by the tip being too blunt or instable. This means that you should stop measuring and cut a new tip:

➔ Click Stop and follow the instructions of the *Chapter 9: Problems and solutions* (page 78).

If the line in the Line graph is calm and reproduces consistently, you can continue with the next section.

4.5: Achieving atomic resolution

4.5.1: General instructions

Once the Topography in the Line graph is reproducing stably, the scan range has to be decreased in order to observe atomic structures.

IMPORTANT

Measurements on the micrometer/nanometer scale are very sensitive to environment influences. Direct light or fast movements — causing air flow and temperature variations near the Scan Head — can influence and disturb the measurement. It is best to let a promising measurement run for some time in order to stabilize thermally.

To decrease the Imaging area:

1. Click the Color map chart to make it active.
   A gray square is now drawn around the Color map chart.
2. Click Zoom.
   The mouse pointer becomes a pen when moving over the selected chart and and the Tool Results Panel opens.
3. Move the mouse cursor to a "flat" region (similar color) in the Color map and click on it.
   The software will now draw a square that indicates the new scan range. The size of the new scan range is displayed in the Tool Results Panel (see *Figure*

4-4: Zooming). If no flat region is available, refer to *Chapter 5: Improving measurement quality* (page 56) for further instructions.

❹ Change the size of the new scan range to about 30–50 nm by clicking and dragging a corner of the square with the mouse cursor.

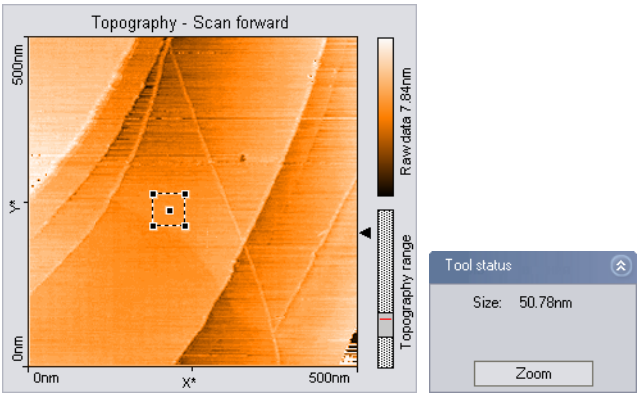


Figure 4-4: Zooming. (left) Square drawn in the Color map. (right) New scan range as displayed in the Tool Results Panel.

❺ Double click the chart when the scan new area is set as you want it. You can abort the zoom function by clicking with the right mouse button.

The imaging settings are now set in such a manner that the new measurement will correspond to the area that was indicated by the square.

❻ Let the Topography reproduce stably again.

To achieve atomic resolution, the image size should be decreased even further, considering that one nanometer is the diameter of between four and eight atoms. Atomic arrangements can normally be recognized at an image size of about 4 nm. Therefore:

➲ Set the Image size in the Imaging panel to 4 nm.

Some parts of the scan head react to the slightest temperature changes. As these thermal "movements" influence the measurements on the nanometer scale, the sample has to be scanned as fast as possible:

➲ Set the Time/Line in the Imaging Panel to 0.06s for atomic resolution.

You may also try to decrease noise by decreasing the Loop gain of the Z-Controller. Try varying all of the above parameters to get a good image (such as the one in *Figure 4-5: A successful graphite measurement*).

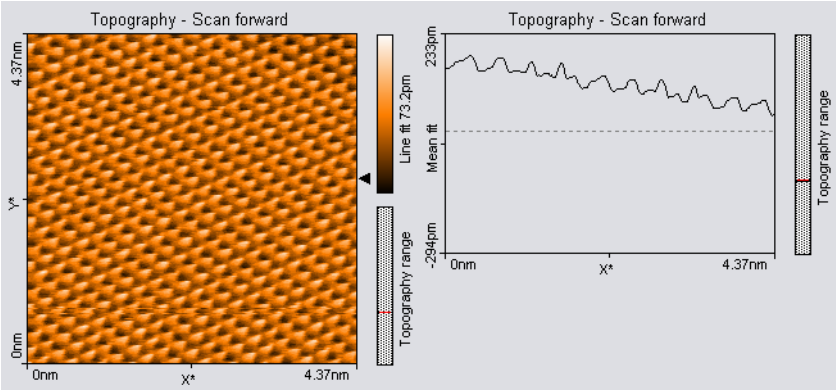


Figure 4-5: A successful graphite measurement

When you're satisfied with the image quality obtained, you may want to save the measurement. Refer to *Section 4.6: Storing the measurement* (page 51) for details on how to do this.

4.5.2: The graphite surface

In a good color map chart of graphite you will see a pattern consisting of bright, intermediate, and dark spots. It looks like a three dimensional image of balls lying next to each other, but be careful: these are not the single atoms!

To interpret the image correctly you must first be aware that bright spots show high points and dark spots low ones.

In the lattice model of graphite (*Figure 4-6: The graphite surface* (page 50)) one can see that there are two different positions of the carbon atoms in the graphite crystal lattice: one with a neighboring atom in the plane below (gray) and one without a neighbor in the lattice below (white). As a consequence, the electrical conductivity of the graphite surface slightly varies locally, so that the atoms without neighbors appear higher than the others.

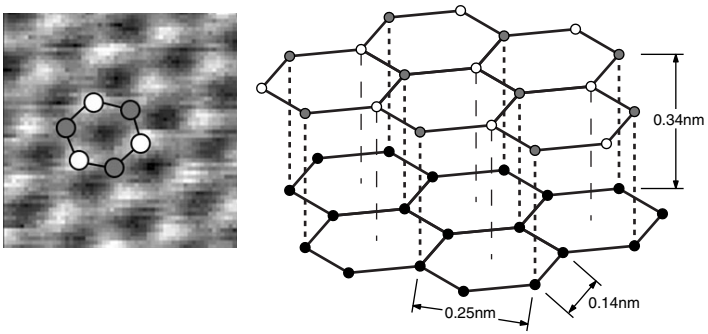
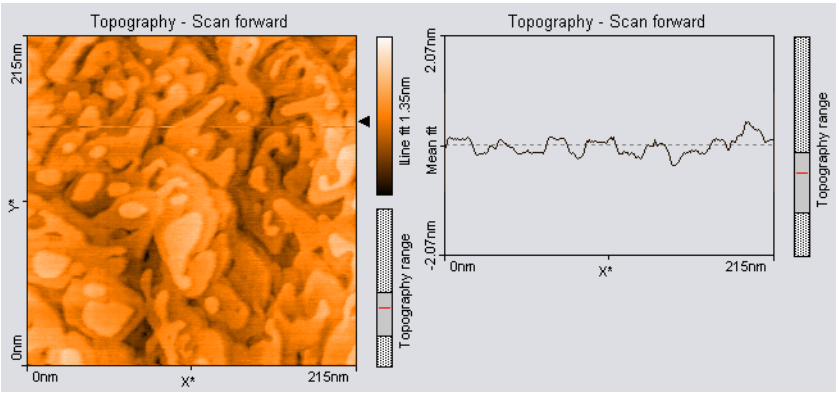


Figure 4-6: The graphite surface. (left) Measurement. (right) Lattice model.

This also causes the lattice constant between the bright "hills" to have the higher than normal value of 0.25 nm.

4.5.3: Measuring Gold

It is more difficult to obtain good images of gold. Atomic structures are difficult to observe, because the electrons on the surface are much more homogeneously distributed than in graphite. But, with some training, the mono-atomic gold steps can be observed.



Since the gold sample cannot be cleaned by simple means, it is possible that over time contaminants may prevent you from obtaining good results. If you have

problems measuring the gold sample because of this issue, please order a replacement from your local Nanosurf distributor.

Tip

Before performing any experiments with the gold sample it is necessary to practise on the graphite sample. The graphite sample is also a good test sample to judge the quality of the installed STM tip.

To perform measurements on gold:

➲ Proceed as describe for the graphite sample, but with the following changes to the settings:

- Set the Tip voltage in the Z-Controller panel to 0.5 V.
- Set the Time/Line in the Imaging Panel to 0.3 s.

If you do not get stably reproduced scan lines, try to re-approach:

➲ Press Withdraw followed by Approach.
If that does not change much, retract the sample holder, rotate it a little by hand and repeat the approach.

If the image reproduces stably:

➲ Select an Image size between 200 and 300 nm, and evaluate your measurements in the same way as you did with the graphite images.

4.6: Storing the measurement

When you are satisfied with your image and would like to keep it, you can take a snapshot of it by clicking Photo. The behavior of this button depends on whether a measurement is in progress or not:

- When a measurement is in progress and Photo is activated, a copy of the measurement is made to a measurement document after the measurement is finished.
- When the measurement is not in progress and Photo is activated, a copy is made immediately.

If you want to save the new measurement document to your hard disk drive (for example for loading it into the Nanosurf Report software later):

1. Activate the measurement document by clicking in its window, or by selecting it in the "Windows" menu.
2. Select the menu "File" >> "Save as..." and select the folder and name where you would like to store the measurement.

The stored measurements can now be loaded with the easyScan 2 STM software or the optional Nanosurf Report and Nanosurf Analysis software packages for later viewing, analysis, and printing. A brief introduction on how to create a basic report using the Report software is given in the next section. For more detailed information on starting and using the Report software, see *Section 20.2: Creating a report* (page 214), or refer to the Nanosurf Report online help.

4.7: Creating a basic report

The optional Nanosurf Report software can be used to evaluating the measurement, and to create visually appealing reports. Here, we will just start the software and create a basic report.

To start the Report software:

- Click  in the Navigator.
  The Report software will now start, open the currently selected measurement, and evaluate it using the default template.

IMPORTANT

After a fresh installation of the Report software, the Report software has to be run at least once before it can be automatically started from within the easyScan 2 software. To run the Report software for the first time, select it from the Microsoft Windows "Start" menu.

4.8: Further options

From this point on, there are several things that can be done. Please refer to the respective chapters for detailed instructions:

- Performing a new measurement on another sample by repeating the instructions given in *Chapter 3: Preparing for measurement* and *Chapter 4: First measurements* with the new sample.
- Improving measurement quality, as described in *Chapter 5: Improving measurement quality* (page 56).
- Performing a different type of measurement by choosing a different operating mode, as described in *Chapter 6: Operating modes* (page 66).
- Finishing measurements, turning off the instrument, and/or storing the instrument, as described in *Chapter 7: Finishing measurements* (page 70).

CHAPTER 5:

Improving measurement quality

Chapter 5: Improving measurement quality

5.1: Removing interfering signals

Interfering signals can be recognized because they have a fixed frequency, usually a multiple of the local mains frequency (50 or 60 Hz) throughout the image. Thus, they are manifested by straight lines that run throughout the entire image.

Possible interference sources are:

- *Mechanical vibrations* from machines or heavy transformers in direct vicinity (e.g. pumps).
- *Electrical interference* (in the electronics, or in electrical forces of the tip–sample interaction).

5.1.1: Mechanical vibrations

Measure the frequency of the vibrations to find out if the interference is due to mechanical vibrations. Such vibrations have a frequency that is (a multiple of) the rotation frequency of the source. This frequency is usually not a multiple of the local mains frequency, and may change slightly over time. Try the following to find out if the interfering signal is due to mechanical vibrations:

1. If possible, turn off all rotating machines (i.e. pumps) in the room.
2. Change the vibration isolation by putting the Scan Head directly on the table, instead of on the Sample stage.

To reduce the influence of these vibrations, either improve the isolation of these machines, or improve the isolation of the instrument by using a vibration isolation table (e.g. the optional TS-150 active vibration isolation table).

5.1.2: Electrical interference

Electrical interference may be caused by interference in the electronics, or by electrostatic forces acting between the tip and the sample. Try the following in order to reduce the influence of electrical interference:

1. Connect the instrument to the mains power supply using sockets with line filters and surge protection.

❷ Remove interfering electromagnetic field sources, such cathode ray tube displays, loudspeakers, …

5.2: Decreasing thermal drift

Temperature variations cause so-called “thermal drift”. This will cause images to be distorted. This effect is present when the observed upward scan is very different from the downward scan, for example showing two differently distorted lattices.

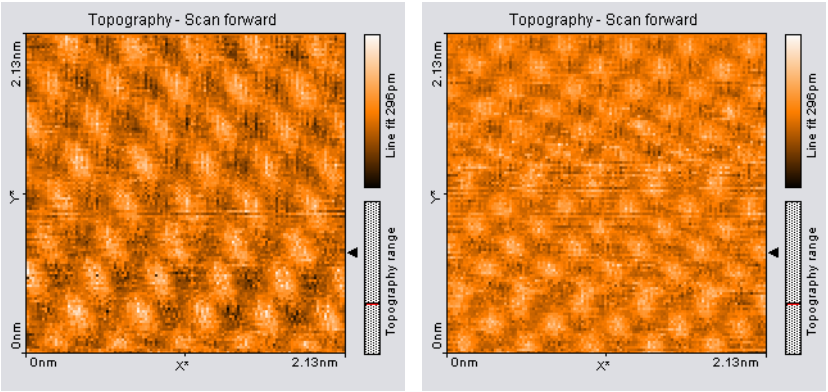


Figure 5-1: Consecutive upward and downward scan showing thermal drift.

Thermal drift is very clearly visible on an atomic scale. Variations of 0.1°C already cause variations of several nanometers in length of (for example) the steel sample holder.

To decrease thermal drift, keep the measurement running for some time to let the system stabilize (up to about one hour), and prevent air currents in the room from reaching the scan head.

5.3: Adjusting the measurement plane

Ideally, the sample surface and the XY-plane of the scanner run parallel to each other. In most cases, however, the sample plane is tilted with respect to the XY-plane of the scanner. In this case, the sample cross section in the X* measurement

direction has a certain slope. The Line graph chart in *Figure 5-2: Maladjusted slope* is an example.

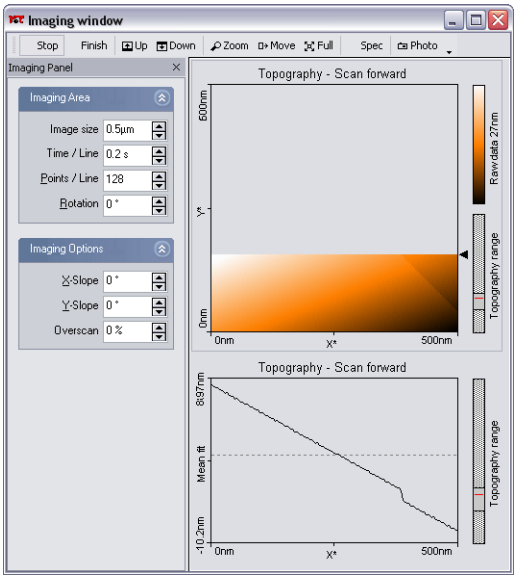


Figure 5-2: Maladjusted slope. Measurement with improperly set X*-slope.

This slope depends on the direction of the X* direction and therefore on the rotation of the measurement, as shown in *Figure 5-3: Sample and measurement orientation before slope adjustment*.

This slope is undesirable for several reasons:

- It makes it difficult to see small details on the sample surface, because the Average, Plane fit, or higher order filters cannot be used properly.
- The Z-Controller functions less accurately, because it continuously has to compensate for the sample slope.

During measurement, the measurement plane should therefore be adjusted electronically using the parameters “X-Slope” and “Y-Slope”.

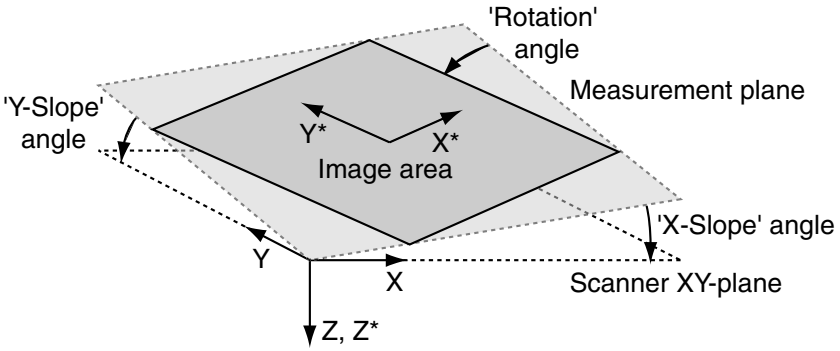


Figure 5-3: Sample and measurement orientation before slope adjustment

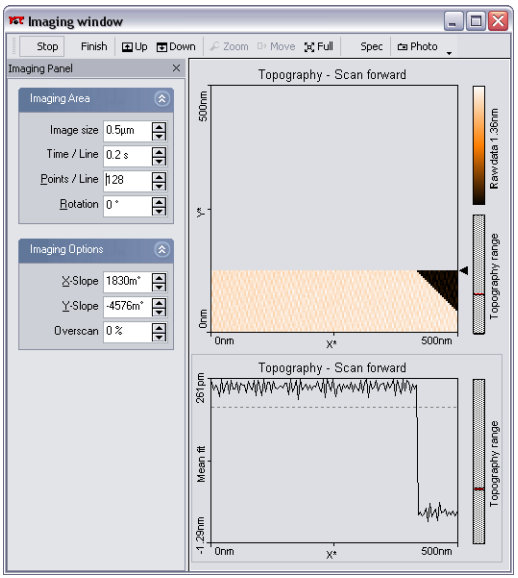


Figure 5-4: Adjusted slope. Measurement with properly set X*-slope.

To determine the correct values, use the following procedure:

❶ Open the User interface dialog via the menu “Options/Config user interface, and select one of these modes. The slope correction is only available with the Standard and the Advanced level user interface mode.

❷ Measure the slope in the Line graph using the angle tool (as detailed in *Section 19.2: The Tools bar* under *Measure Angle* (page 201)).
Use a single click to measure the angle relative to the X*-Axis.

❸ Alter the value of "X-Slope" in the Imaging options of the Imaging panel until the X-axis of the scan line lies parallel to the X-axis of the sample.

❹ Set Rotation to 90° to scan along the Y-direction of the scanner.

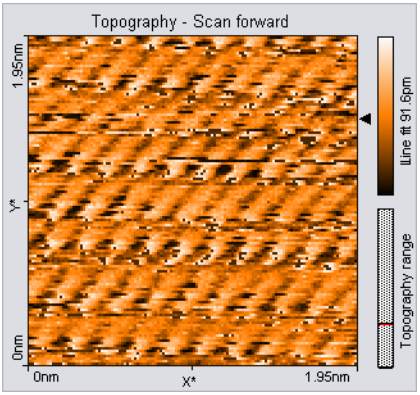
❺ If the scan line is not horizontal, alter the value for "Y-slope" until the Y-axis of the scan lies parallel to the Y-axis of the sample.

❻ Reset "Rotation" to 0°.
The Line graph shows the X-slope again.

5.4: Judging tip and tunneling contact quality

When all prerequisites for measurement are optimal, the measurement quality mainly depends on the quality of the tip and of the tunneling contact. A sharp tip and a good tunneling contact are necessary for high quality images of atomic resolution.

If during a good measurement the image quality diminished dramatically, the tip has most probably picked up some particles or you are near a step in the surface.



In this case:

➲ Continue measuring for a while (4–5 images).
The tip may eventually lose the picked up material again.

If this does not help, try to induce changes at the tip's end using one of the following procedures:

- While measuring, increase the gap voltage in the "Feedback Panel" to 2 V and then reduce it to the old value again.
- Increase the tunneling current to 20 nA for a short period of time and then reduce it to its old value again.
- Retract the sample and then perform a new approach.

If no improvement can be seen after going through these procedures, you have to prepare a new tip:

❶ Follow the instructions in *Section 7.1: Finishing scanning* (page 70).

❷ Follow the instructions in section *Section 3.2: Preparing and installing the STM tip* (page 30).

Examples of images made with unusable tips

Prepare a new tip when your image looks like one of the examples below.

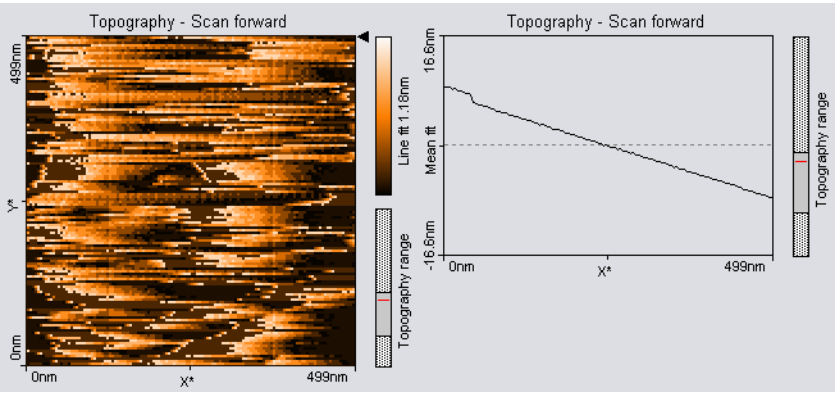


Figure 5-5: The color map image consists of uncorrelated lines.

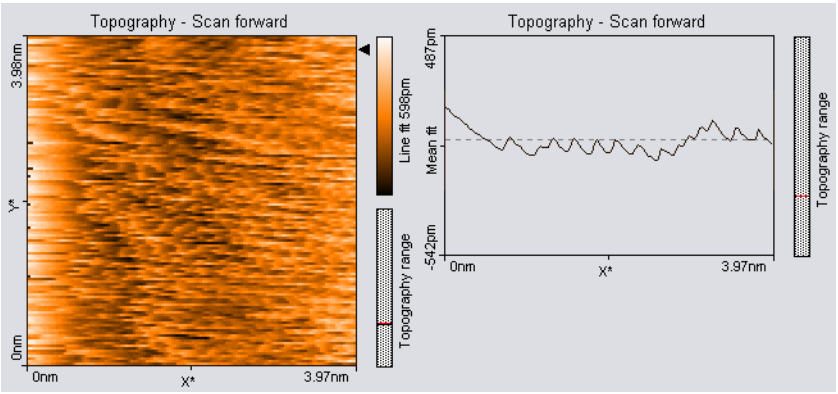


Figure 5-6: The image is “smeared out” on one border (here on the left border).

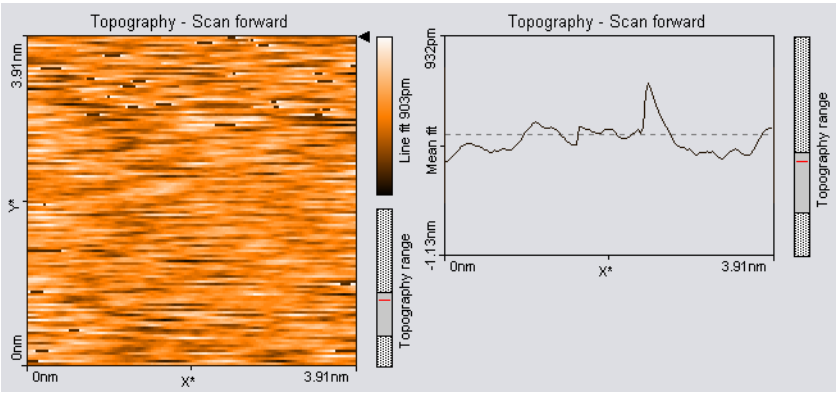


Figure 5-7: Each image looks different.

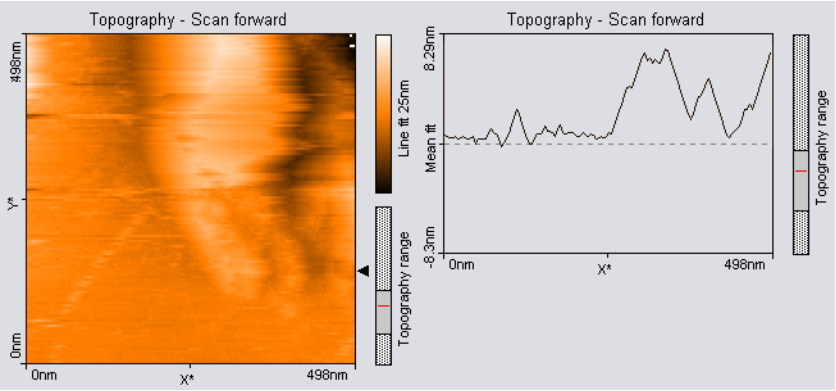


Figure 5-8: The scan lines in Line graph are unstable and the image in the Color map is blurred.

CHAPTER 6:

Operating modes

Chapter 6: Operating modes

With an STM, the sample surface can be scanned in two different ways: by using *Constant Current mode* or by using *Constant Height mode*. Read the following sections for details.

6.1: Constant Current mode

In Constant Current mode, the tunneling current is kept constant by the Z-Controller. The output of the Z-Controller thus corresponds to the height of the sample surface. This output is recorded as a function of X and Y position, and is displayed as the Topography signal.

6.2: Constant Height mode

In Constant Height mode on the other hand, the tip does not follow a surface of constant tip current. Instead the variation of the tunneling current is directly recorded as a function of the X and Y position in plane parallel to the sample surface.

The easyScan 2 STM is normally configured to measure in the Constant current mode. To switch to the Constant height mode, you could theoretically just turn off the Z-Controller. However, several problems arise:

- The tip would crash into the slightest unevenness of the surface.
- The scan plane of the scanner must be very well adjusted to the plane of the sample.
- The thermal drift in the Z-Direction will cause the tip to rapidly move away from the sample, or even worse, to crash into it.

For a large part, these problems can be avoided by setting the Loop gain to a very low value. Thus, the feedback loop can follow the slow movement of the sample caused by thermal drift and the sample plane, but not the fast height changes due to the presence of the atoms.

To measure in Constant height mode:

1. Find a flat area of the sample by imaging it in Constant current mode, and zoom in on this area.

❷ Open the User Interface configuration dialog using the menu "Options" >> "Config User Interface...".

❸ Set the User Interface Mode to "Standard level" or "Advanced level".

❹ Click  to open the Z-Controller Panel.

❺ Set I-Gain to 4.

❻ Set P-Gain to 0.

To visualize the current:

❶ Click on a Color map chart in the Imaging Window.

❷ Set the Input channel to "Tip Current" in the chart bar.
The bar next to Color map should now display the text "Tip Current" and should have the units "pA" or "nA" instead of "nm".

CHAPTER 7:

Finishing measurements

CHAPTER 7: Finishing measurements

7.1: Finishing scanning

Once you are done measuring:

1. Click Stop to stop measuring.
2. Retract the sample holder first by using Withdraw then Retract.
3. Remove the magnifying cover from the scan head.
4. Remove the sample holder with one hand.
5. Remove the sample from the sample holder and store it in its case with the other hand.
6. Store the sample holder in its container.

7.2: Turning off the instrument

To turn off the instrument:

1. Finish as described in *Section 7.1: Finishing scanning*
2. Verify that you have saved all measurements that you would like to keep (see *Section 4.6: Storing the measurement* (page 51)).
3. Exit the easyScan 2 control software.
   If you exit the program while still having some unsaved measurements, you will be asked to save them.
4. Turn off the power switch (see *Figure 1-4: The easyScan 2 controller* (page 17) for its location).

If you perform measurements regularly:

- Leave the instrument with the Magnifying cover over the scan head to protect it against dust.

If you do not operate the instrument for several weeks:

- Store the instrument as is described in *Section 7.3: Storing the instrument.*

7.3: Storing the instrument

If you are not using the instrument for an extented period of time, if you have to transport it, or if you send it in for repairs, put the instrument in the original packaging material or instrument case.

1. Turn off the instrument as described in *Section 7.2: Turning off the instrument*, and remove all cables.
2. Remove the Sample and Sample Holder. The tip can be left in the scanner.
3. Store the Sample Holder in its container.
4. Pack all components in the original Nanosurf packaging material or instrument case, as shown in *Figure 7-1: Packing*.

IMPORTANT

Before transport, always put the instrument in the original Nanosurf packaging material or instrument case.



Figure 7-1: Packing. The easyScan 2 STM system packed in the Instrument Case.

CHAPTER 8:

Maintenance

Chapter 8: Maintenance

To ensure fault-free operation of the microscope the following instructions for maintenance have to be followed.

8.1: Scan Head

It is very important to keep the Sample Holder and the open parts of the scanner clean. If exposed to moisture (high humidity), corrosion will occur.

8.1.1: Protecting the sample holder against corrosion

The sample holder is made of magnetic steel and therefore suffers from corrosion in a humid environment. The approach motor will not run well if the sample holder is dirty or corroded. To reduce corrosion and increase life expectancy, the sample holder must be stored in its container together with the moisture absorbing silica container. The container is waterproof but not airtight. The silica contains a blue indicator which turns pink when saturated.



Figure 8-1: STM Sample Holder Container. (from left to right) Screw cap, Sample holder, Silica container, Sample Holder Container.

To regenerate the silica:

➲ Heat the silica container at 100°C for at least two hours until it turns completely blue again.

8.1.2: Cleaning parts of the approach motor

If you have touched the metal part of the sample holder or it has otherwise become dirty, or if the approach motor does not move, the Sample Holder should be cleaned. To do this:

❶ Take a soft cloth, if necessary moistened with alcohol.

❷ Clean the sample holder by moving the cloth along the sample holder in the axial direction.

Do not move it around its circumference!

❸ Let the parts dry before operating the motor again.

If the approach motor still does not move:

❶ Take a cotton swab, if necessary lightly moistened with alcohol.

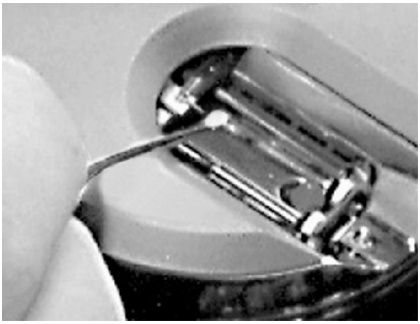


Figure 8-2: Cleaning the sample holder guide bars

❷ Clean the sample holder guide bars (*Figure 8-2: Cleaning the sample holder guide bars*).

❸ Clean the surfaces of the approach motor that touch the sample holder.

❹ Clean the tip holder (remove the tip when doing this).

❺ Let the parts dry before operating the motor again.

8.2: Scan electronics

To clean the case and the controls of the scan electronics:

➔ Use a soft cloth, lightly moistened with a mild detergent solution. Do not use any abrasive pads or solvents like alcohol or spirits.

CHAPTER 9:

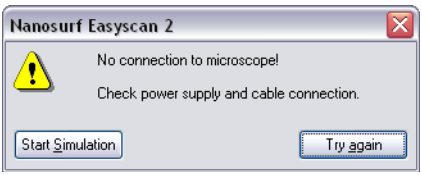
Problems and solutions

CHAPTER 9: Problems and solutions

The problems described here can occur during normal operation of the microscope. If the suggested course of action does not solve the problem, or the problem is not described here, refer to *Section 9.3: Nanosurf support* (page 84).

9.1: Software and driver problems

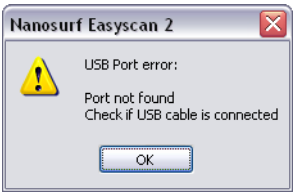
9.1.1: No connection to microscope



This error message appears when the easyScan 2 software is waiting for an answer from the controller. Most likely, the easyScan 2 controller is not connected to the mains power, or it is not turned on. In this case the status lights on the top of the controller are off. To fix this problem:

➲ Check the connections and the power switch.

9.1.2: USB Port error



The USB serial converter is not available. The USB cable is not properly connected. In this case the USB power light on the easyScan 2 controller rear panel) does not light up (*Figure 1-4: The easyScan 2 controller* (page 17)). To fix this problem:

❶ Check if the a second copy of the easyScan 2 is already running and occupying the USB port.

❷ Check that the USB cable is properly connected.

If this does not solve the problem, check if there is a driver problem with the USB Serial port/USB Serial converter drivers, as described in the next section.

9.1.3: Driver problems

If you have trouble connecting to the controller, or if the video image in the positioning window is not available, it is possible that one of the drivers of your instrument is causing problems, for example because the installation did not work, or the installation of some other hardware is in conflict with the drivers of the easyScan 2. In order to solve driver problems:

❶ Check for driver updates on the Nanosurf Support web site.

❷ Insert the installation CD for your instrument.

❸ Log in with Administrator priviliges.

The device manager can then be opened to view and correct any driver problems:

❶ Open the windows menu “Start” >> “Settings” >> “Control Panel”.
The control panel now opens.

❷ Click “Switch to classic view” if you do not see an icon called “System”.

❸ Double-click the System icon.
The System properties dialog now opens.

❹ Select the tab “Hardware”

❺ Click the “Device Manager”-button.
The device manager now opens.

When the device manager opens and your controller is connected to your computer, you may see the drivers shown in *Figure 9-1: Device manager* (information may vary depending on the configuration of your system):

- Generic USB Hub: all systems
- USB Serial converter, USB Serial port: all systems

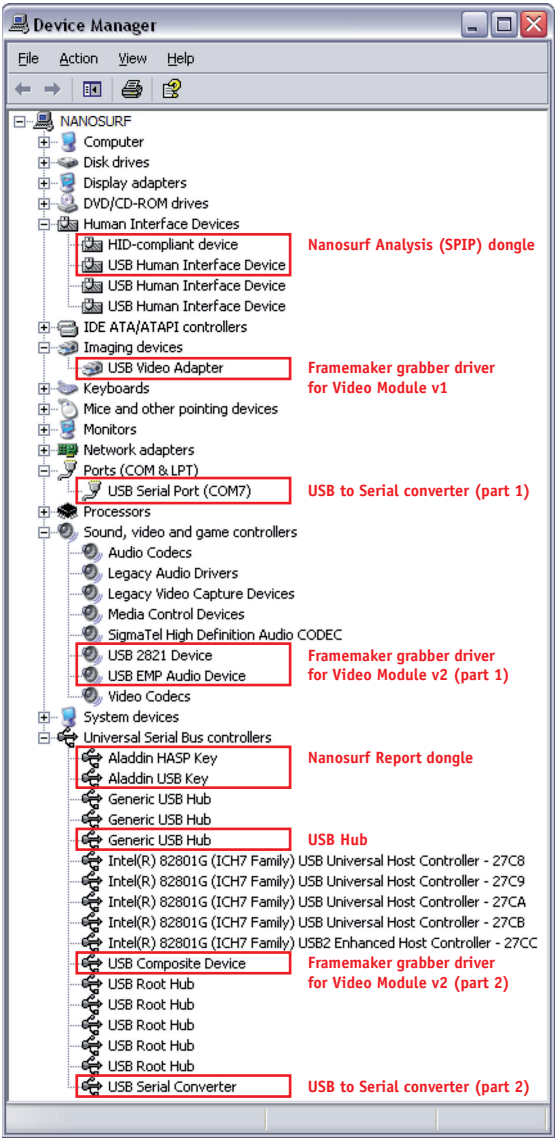


Figure 9-1: Device manager. The drivers that may be installed on your system when your controller is connected to the computer.

- USB Video Adapter: Video Module version 1
- USB Composite device, USB 2821 Device (USB 2.0 A/V Converter), USB EMP Audio Device: Video Module version 2
- HID-compliant device, USB Human Interface Device: Nanosurf Analysis (SPIP)
- Aladdin HASP key, Aladdin USB key: Nanosurf Report

If there are problems with any of these drivers, or a wrong driver is installed, you can try the following to fix it:

1. Double click on the driver.
   Properties dialog for the device now opens.
2. Select the “Driver”-tab.
3. Click the “Update Driver”-button
   Windows will now ask you were to look for the driver.
4. Tell windows to take the driver from the Installation CD.

9.2: STM measurement problems

9.2.1: Manual approach is too slow / stops sometimes

If the manual approach using the approach motor (buttons Advance and Retract) is affected:

- Clean the sample holder guide bars and the surfaces of the approach motor following the procedure described in *Chapter 8: Maintenance* (page 74).

9.2.2: Automatic final approach is too slow / stops sometimes

Even if the manual approach works, the automatic final approach (button Approach) may not work.

- Clean the sample holder guide bars and the surfaces following the procedure described in *Chapter 8: Maintenance* (page 74).

If cleaning does not help, the step size may be too small. To solve this problem:

1. Open the User Interface configuration dialog using the menu "Options" >> "Config User Interface...".
2. Set the User Interface Mode to "Standard level" or "Advanced level".
3. Increase the value of Appr. Speed in the Approach Options section of the Approach Panel by a few percent until the approach works.
   Now the motor moves the sample holder with larger steps during automatic approach.
4. Save the new value of Appr. Speed using the menu "File" >> "Parameters" >> "Save".

9.2.3: Automatic final approach crashes the tip into the sample

In this case the motor moves the sample holder towards the tip with too large steps:

1. Open the User Interface configuration dialog using the menu "Options" >> "Config User Interface...".
2. Set the User Interface Mode to "Standard level" or "Advanced level".
3. Decrease the value of Appr. Speed in the Approach Options section of the Approach Panel by 10%.
4. Repeat the approach with a new tip. If the approach fails again, reduce Appr. Speed further.
5. Save the best Appr. Speed value using the menu "File" >> "Parameters" >> "Save".

9.2.4: Image quality suddenly deteriorates

There are several possible causes for this phenomenon:

Z-Drift

The tip drifted outside the Z-range of the scanner. In this case, the Probe Status light (see *Figure 1-4: The easyScan 2 controller* (page 17)) will either light up orange/yellow or red.

If the light is orange/yellow, the tip has lost contact with the sample:

➔ Click Approach in the Approach Panel then repeat the steps in *Chapter 4: First measurements* (page 40).

If the light is red, the tip has drifted into the sample. You can try to move the sample surface within the Z-range of the scanner, although the tip may already have been damaged:

➔ Click Withdraw in the Approach Panel.

If the light is still red after withdrawing, prepare a new tip (*Section 3.2: Preparing and installing the STM tip* (page 30)).

➔ Click Approach.

XY-Drift

The scanner may have drifted close to a deformity in the sample's surface. Try to find a different measurement position:

1. Increase the scan range.
2. Zoom into a flat area.

Tip modification

The tip may have picked up some particles or other material from the sample surface. In this case, follow the instructions given in *Chapter 5: Improving measurement quality* (page 56).

9.3: Nanosurf support

9.3.1: Self help

The fastest way to solve a problem is often to solve it yourself. If the previously suggested actions did not help, or the problem is not described here, refer to the Nanosurf support pages:

1. Open *www.nanosurf.com*.
2. Click on "Support".
3. Enter the combination of serial number and the password that you received on registering.
4. Select the easyScan 2 link.
5. If the problem is software related, try to upgrade to the latest version and/or read the "What's new file" to see if the problem was solved. For the solution to other problems, refer to the Frequently Asked Questions (FAQ).

If your instrument has not been registered yet, you will first have to register to receive a password.

9.3.2: Assistance

If the standard solutions are not sufficient, contact your local distributor for help. In order to resolve the problem as fast as possible, please provide as much information as possible, such as:

- A detailed description of what happened before the problem occurred. For example: "When I click the 'Approach' button, then quickly click abort, the controller will not react to anything I do anymore. This only happens when measuring in Dynamic Force Mode."
- If an error message was displayed: The exact text of the message, or at least the start of the message.
- The serial number of your Scan Head and/or controller.

- A description of the computer hardware and software on which the control software is running: computer brand, type (laptop or desktop), operating system, software version etc.
- Original Nanosurf image data (.nid) files that show the problem, rather than bitmap screen shots, because these files contain all the settings that were used to make them.
- Parameter (.par) files with the instrument settings that were used when the problem occurred.
- Script files, if the problem occurs during the operation of a script.

IMPORANT

Sending ".vbs" scripts by e-mail often does not work, because these files are usually blocked as a security measure. To successfully e-mail a script, you may either:

- Add the script text to the body of the e-mail.
- Change the extension of the script file to ".txt" and attach it to the e-mail.
- Compress the script file to a ".zip" archive and attach it to the e-mail.

CHAPTER 10:

STM theory

Chapter 10: STM theory

10.1: What is STM?

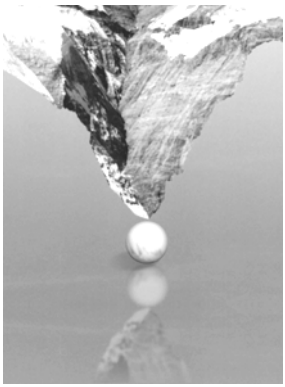
Microscopy is one of the most exciting scientific techniques. The insight into small dimensions has led to a new understanding of the structure of materials and forms of life.

With the help of the scanning tunneling microscope (STM) it is possible to look into the fascinating world of the atoms. This completely new microscopy technique works without focusing elements and features atomic resolution (laterally and vertically).

The Scanning Tunneling Microscope was developed by Gerd Binnig and Heinrich Rohrer in the early 80's at the IBM research laboratory in Rüschlikon, Switzerland. For this revolutionary innovation Binnig and Rohrer were awarded the Nobel prize in Physics in 1986.

In the STM, a small sharp conducting tip is scanned across the sample's surface, so close that the so-called "tunneling current" can flow. With the help of that current the tip-surface distance can be controlled very precisely. Therefore an enormous resolution is achieved so that the atomic arrangement of metallic surfaces can be "probed".

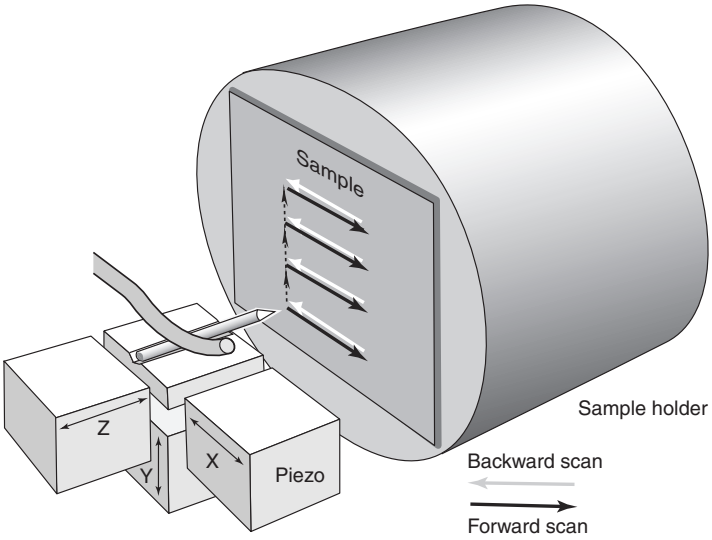
To be able to get such excellent pictures of atomic resolution is almost incredible, considering that the size of the atom in relation to the tip is that of a golf ball to a mountain.



10.2: Scanning with the easyScan 2 STM

In the easyScan 2 STM, a platinum-iridium tip is moved in three dimensions using piezo-crystal translators that are driven with sub-nanometer precision.

The sample to be examined approaches the tip within a distance of 1 nanometer (1 nm= 1 / 1 000 000 000 m). Classical physics would prohibit the appearance of electrons in the small gap between a tip and a sample, but if a sharp tip and a conducting surface are put under a low voltage (U~0.1V), a very small tunneling current (I~1nA) may nevertheless flow between tip and sample. This tunneling current is due to a quantum physics effect.



The strength of the tunneling current depends exponentially on the distance between the tip and the sample (usually referred to as Z-distance). This extreme dependence on the Z-distance makes it possible to measure the tip–sample movement very precisely. One of the three piezo crystals, the Z-piezo, can now be used in a feedback loop that keeps the tunneling current constant by appropriately changing the Z-distance.

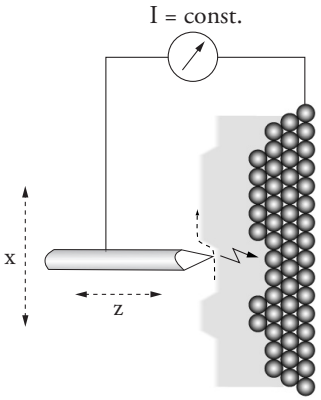


Figure 10-1: Feedback loop. The feedback loop maintains a constant tunneling current between the tip and the sample during motion in the X-direction by changing the Z-direction (viewed from top)

To obtain an image of the sample, the tip is scanned using the X- and Y-piezo crystals. The feedback loop will now let the tip follow the structure of the sample's surface. A height image can now be made by recording the position of the Z-feedback loop as a function of the XY-piezo position. This "landscape" (or topography) of the atomic surface is then drawn line by line on the computer screen.

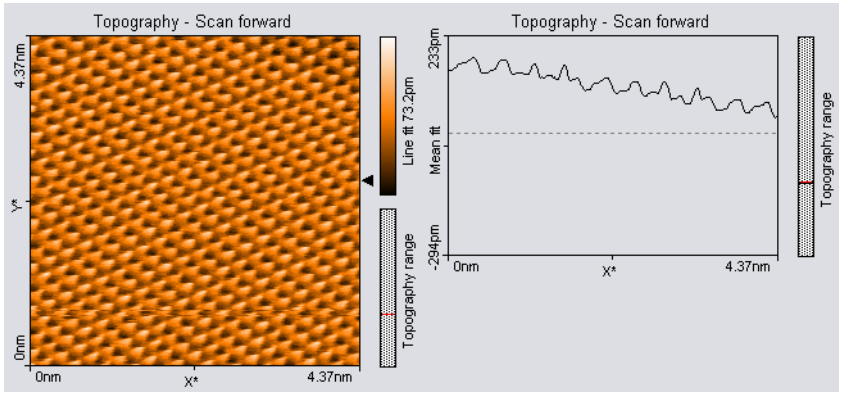


Figure 10-2: STM image of graphite

The sample can also be scanned in a second mode: When the feedback loop is slowed down very much, the tip scans at a fixed distance from the sample (constant height mode). This time the variations in the tunneling current are measured and drawn line by line on the computer screen. However, this mode only works when the sample is atomically flat, because the tip would otherwise "crash" into the sample.

CHAPTER 11:

Technical data

Chapter 11: Technical data

11.1: Specifications and features

The specifications given here are typical values of the Nanosurf easyScan 2 STM system. The exact specifications vary somewhat from instrument to instrument, and are given on the calibration certificate delivered with the instrument.

11.1.1: The easyScan 2 Controller

Electronics

Controller size / weight:	470×120×80 mm / 2.4 kg
Power supply:	90–240 V AC, 50/60 Hz, 30 W
Computer interface:	USB 2.0 (Appr. controller serial number 23-06-030 and higher)
Integrated USB hub:	2 Ports (100 mA max)
Scan generator:	16 bit D/A converter for all axes
Scan drive signals:	±10 V, no high voltage
Scan speed:	Up to 60 ms/line at 128 data points/line
Measurement channels:	16 bit A/D converters, up to five signals depending on mode.
Scan area and data points:	Individual width/height, up to 2048×2048 points
Scan image rotation:	0–360°
Sample tilt compensation:	Hardware X/Y-slope compensation
Spectroscopy modes:	Single point measurement or multiple measurements along a vector
Spectroscopy data points:	Up to 2048
Spectroscopy measurement averaging:	Up to 1024 times

easyScan 2 Software

Simultaneous display of data in charts types:	Line graph, Color map, 3D view, …
User profiles:	Customizable display and parameter settings
online processing functions:	Mean fit, Polynomial fit, Derived data, …
Quick evaluation functions:	distance, angle, cross section, roughness, …
Data export:	TIFF, PNG, BMP, ASCII, CSV, …

Nanosurf easyScan 2 Scripting Interface

Applications:	Automating measurement tasks, lithography, custom evaluation functions, using third party measurement equipment
Included control software:	Windows Scripting Host: Visual Basic Script, Java Script, …
Remote control by:	COM compatible languages: LabView, MathLab, Visual Basic, Delphi, C++, …

Computer requirements

Operating system:	Windows 2000 / XP / Vista
Required hardware:	USB 2.0 connector
Recommended hardware:	Pentium 4/M or AMD Athlon (or better), 256 MB RAM, True color >1024×786 resolution video card, Hardware Open GL accelerator

Computer not included with system

Nanosurf easyScan 2 Signal Module S

Available output signals:	X-Axis, Y-Axis, Z-Axis, Approach, Tip Voltage, STM Current or AFM Deflection, Excitation, Amplitude, Phase
Full scale corresponds to:	±10 V, Excitation: ±5 V
Power supply output:	GND, +15 V, -15 V

Nanosurf easyScan 2 Signal Module A

Output signals:	All output signals of Signal Module: S
Additional analog user outputs:	2 × 16 bit D/A converters, ±10 V
Synchronization output:	1 × TTL: start, end, point sync
Additional signal modulation inputs:	X-Axis, Y-Axis, Z-Axis, Tip Voltage, Excitation
Free connectors:	2 × Aux, connection made on user request
Modulation range:	±10 V, Excitation: ±5 V
Additional analog user inputs:	2 × 16 bit A/D converters, ±10 V
Additional modes:	Almost unlimited

User inputs can optionally be measured in all Imaging and Spectroscopy modes.

User outputs can be modulated in Spectroscopy measurements.

11.1.2: The easyScan 2 STM Scan Heads

STM Scan Head:	500 nm	1 µm	500 nm LC	1 µm LC
Maximum Scan range[1)]	500 nm	1.0 µm	500 nm	1.0 µm
Maximum Z-range[1)]	200 nm	200 nm	200 nm	200 nm
Drive resolution Z[2)]	3 pm	3 pm	3 pm	3 pm
Drive resolution XY[2)]	7.6 pm	15 pm	7.6 pm	15 pm
Current set point	0.1-100 nA in 25 pA steps		0.02-20 nA in 5 pA steps	

(1) These are typical values, the exact values are given on the calibration certificate that is delivered with the instrument.

(2) Calculated by dividing the maximum range by 16 bits; atomic resolution on HOPG can be obtained with all STMs

11.1.3: Operating modes

Imaging modes	Constant Current (Topography), Constant Height (Current)
Spectroscopy modes	Current-Voltage, Current-Distance
Tip voltage	±10 V in 5 mV steps
tip–sample approach	Stick-slip piezo motor
Sample size	max. 10 mm diameter

11.2: The Signal Modules

The Signal Modules consist of electronic modules that are built into the easyScan 2 controller as well as of a Break-Out Connector that is externally attached to the controller. The Signal Modules can be used for monitoring signals (Signal Module S) and for adding functionality to the easyScan 2 system (Signal Module A). Signal Module A includes all the monitoring functions of

Signal Module S. For information on installing the Signal Modules, refer to *Section 2.1: Installing the hardware* (page 20).

11.2.1: Signal Module S

Signal Module S can be used for monitoring signals from the AFM with external instruments, such as Volt-meters, oscilloscopes or spectrum analyzers. The signals are available on nine BNC connectors that are labelled with their signal names. The signal names and their function are listed in the table *Table 11-1: Monitor signals* (page 99).

The calibration of the monitor signals can be found by looking up the signal calibration in the Scan Head Calibration Dialog, reached via the menu "Options" >> "Config Scan Head...". The magnitude of the physical signal can be calculated from the Monitor Signal voltage using the formula:

$$PhysicalSignal[Unit] = \frac{MonitorSignalVoltage}{10[V]} \cdot Maximum + Offset$$

In addition to the monitor voltages, +15V and –15V voltage sources are available for driving small home-made electronics. The voltages are available on a three-pole mini-DIN connector. The pin-out of this connector is shown in *Figure 11-1: Voltage source connector* (page 100).

11.2.2: Signal Module A

Signal Module A can be used to add functionality (custom operating modes) to the easyScan 2 system, in addition to the applications of Signal Module S. The signals are available on twenty-one BNC connectors that are labelled with their signal names. The signal names and their function are listed in *Table 11-1: Monitor signals* and *Table 11-2: Custom operating mode signals*.

The sum of the modulation inputs and the output value (for example of X-Axis) should not exceed the –10V to +10V range. The Excitation signal should not exceed the –5V to +5V range.

In addition, –15V and +15V voltage sources are available for driving small home-made electronics. The voltages are available on the same type of three-pole

Signal name	Function
X-Axis	X-Position command of the Scanner. Is affected by Image X-Pos and the Imaging Area Rotation.
Y-Axis	Y-Position command of the Scanner. Is affected by Image X-Pos and the Imaging Area Rotation.
Z-Axis	Z-Position command of the Scanner. Is affected by the Z-Controller output, Ref. Z-Plane, X- and Y-Slope.
Tip Voltage	The voltage applied to the tip.
Approach	The voltage ramp that drives the approach motor.
Excitation	No signal (for AFM only).
Deflection	The tip current (see below).
Amplitude	No signal (for AFM only).
Phase	No signal (for AFM only).

Table 11-1: Monitor signals

Signal name	Function
Sync	An output that can be used to synchronize external equipment with the easyScan 2 controller. This feature can be controlled with the scripting interface. For more information, refer to the Script Programmers Manual, topic “Object Reference” >> “Class Scan” >> “SyncOutMode” and “Object Reference” >> “Class Spec” >> “SyncOutMode”
User 1 Output	An analog output that can be used to drive external instruments using the controller. The User output can be used for special spectroscopy measurements.
User 2 Output	An analog output that can be used to drive external instruments using the controller. The User output can be used for special spectroscopy measurements.
X-Axis Input	The Input voltage is added to the X-Position command of the scanner.

Table 11-2: Custom operating mode signals

Signal name	Function
Y-Axis Input	The Input voltage is added to the Y-Position command of the scanner.
Z-Axis Input	The Input voltage is added to the Z-Position command of the scanner. If the Z-Controller is turned on, it will try to compensate this voltage, as a result of which the Input voltage will be added to the topography measurement.
Tip Voltage	The input voltage is added to the Tip-voltage set in the software.
Excitation Input	No function (for AFM only).
User 1 Input	An analog input that can be used to record the signal from external instruments in Imaging and Spectroscopy measurements.
User 2 Input	An analog input that can be used to record the signal from external instruments in Imaging and Spectroscopy measurements.
Aux 1	A connector that can be used for accessing signals that are not otherwise available. Contact your local distributor if you need to use this connector.
Aux 2	A connector that can be used for accessing signals that are not otherwise available. Contact your local distributor if you need to use this connector.

Table 11-2: Custom operating mode signals

mini-DIN connector that is used in the Signal Module S. The pin-out of this connector is shown in *Figure 11-1: Voltage source connector*.

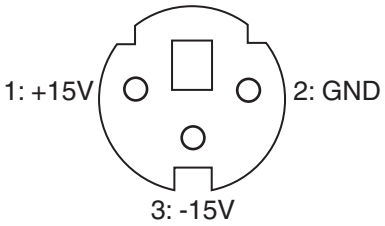


Figure 11-1: Voltage source connector. Connector as seen from outside.

11.2.3: Using the User Inputs and Outputs

The User Inputs and Outputs can be accessed through the Operating mode panel. Each signal can be calibrated with the User Signal Editor that is accessed by clicking on the corresponding "Config" button. This Section is only available in the Advanced user interface level. Refer to *Section 13.1.3: The User Signal Editor* (page 117) for a more detailed explanation.

Various other User Input and Output settings can be configured in the Signal Module Configuration dialog. Refer to *Section 13.6: The Signal Module Configuration dialog* (page 137) for details on how to change them.

CHAPTER 12:

The control software user interface

Chapter 12: The control software user interface

This chapter explains the general concepts of the user interface of the easyScan 2 software. These functions are:

- Setting up the Nanosurf easyScan 2 Controller,
- Moving toward the measurement position,
- Performing measurements,
- Displaying the measurement results,
- Evaluating the measurements,
- Permanently storing measurements and instrument.

These functions can be accessed via the easyScan 2 Software, which is called "workspace". In the following, the workspace will be explained first, then the actual functions of the software will be discussed in more detail. The workspace of the easyScan 2 Software consists of the following parts:

1. The main window,
2. Operating windows,
3. Measurement document windows,
4. Tool bars,
5. Control panels.

12.1: The main window

The main window is opened as soon as the easyScan 2 software starts. It gives access to the whole functionality of the easyScan 2 software, and contains all other windows:

- The Main menu.
- Operating windows that are used to perform specific operations with the microscope.
- Measurement document windows that are used to evaluate previously performed measurements.

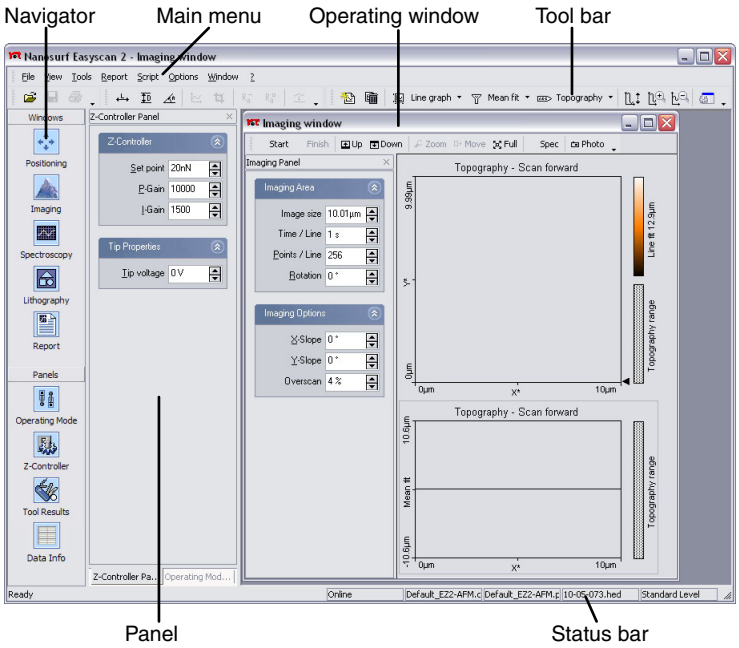


Figure 12-1: The main window

- Several tool bars that are used to issue commands.
- Several control panels that are used to set measurement parameters.
- The Navigator that is used to quickly select between the most often used operating windows and panels.
- The Status bar that displays the state of the instrument.

12.2: Operating windows

Operating windows are used to perform specific operations with the microscope. These operations are controlled using specific panels and tool bars that are part of these windows. The Operating windows are:

- Positioning window: positioning the tip with respect to the sample, with the aid of the optional optical microscope (*Chapter 14: Positioning (page 141)*).

- Imaging window: generating images of the sample (*Chapter 15: Imaging* (page 148)).
- Spectroscopy window: measuring various "A as a function of B" curves at certain sample locations, such as force-distance curves, or current-voltage curves (*Chapter 16: Spectroscopy* (page 158)).
- Lithography window: performing Lithography on the current scan area (*Chapter 17: Lithography* (page 166))

12.3: Measurement document windows

The Measurement document windows visually represent previously made measurements. They are created when you decide to keep the current measurement result. The measurement documents are used for storing, loading, printing and evaluating measurements. The measurement document is described in more detail in the *Chapter 18: Viewing measurements* (page 185) and *Chapter 20: Storing and processing data* (page 211).

12.4: Tool bars

The tool bars can either be free floating windows (Figure below, left), or they can be "docked" to the top or the sides of the window they are associated with (Figure below, right). Most tool bars dock to the Main window, some dock to a task specific window.



12.4.1: Arranging tool bars

The tool bars have several features that allow you to arrange them in a way that is most efficient for your application:

- To display a tool bar that is invisible, select the window it is associated with, and tick the tool bar name in the View menu.
- To dock a tool bar to the sides of its associated window, or to the side of, or

below another tool bar that is already docked to this window, drag its title bar using the mouse cursor.

- To move a docked tool bar, use the mouse cursor to drag its handle on the left side of the tool bar. When the mouse cursor is over the handle, the cursor changes to a four pointed arrow.
- To un-dock a docked tool bar, double click its handle, or drag the handle outside the area reserved for tool bars on the sides of its associated window.

12.5: Control panels

Just like the tool bars, control panels can be either be free floating windows, or they can be "docked" to the sides of the window they are associated with. Most control panels dock to the Main window, some dock to a task specific window. The control panels give access to specific functions of the easyScan 2 STM. The control panels contain one or more function sections, that can be collapsed and opened by clicking on the section header.

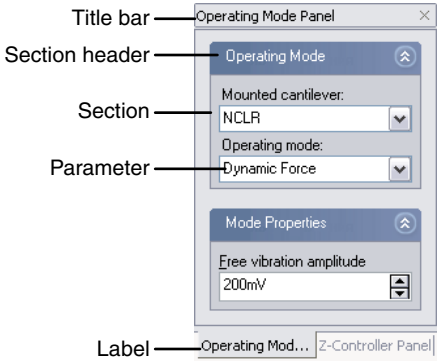


Figure 12-2: A stack of panels

The number of visible sections and the number of visible parameters depends on the user interface mode selected in the User Interface Configuration dialog (*Section 12.6: The User Interface dialog* (page 110)). To see in which user interface mode a certain parameter is available, look at the title of the manual section in which it is described.

12.5.1: Arranging control panels

The control panels have several features that allow you to arrange them in a way that is most efficient for your application.

A control panel associated with the main window is opened and brought on top of the other windows by clicking on its icon in the navigator. Any control panel can be opened and brought on top of the other windows, by selecting the window it is associated with, and ticking the panel name in the View menu.

Control panels can be stacked to save display space. When panels are stacked, labels are displayed on the bottom of the control panel stack. To put a control panel on top of the stack, click its label. To add a control panel to a stack, drag either its title bar or its label to either the title bar or labels of the stack. To remove a panel from a stack, drag its label away from the stack.

To dock a (stack of) panel(s) to the side of its associated window, or to the side of/below another panel that is already docked to this window, drag its title bar to the desired position using the mouse cursor.

It is possible to scroll the content of a control panel up and down, when it is too small to display all the parameters it contains. To do this, move the mouse cursor over an area where it changes to a four pointed arrow. Then, drag the content up and down with the mouse cursor.

12.5.2: Storing and retrieving the workspace

When panels are opened, they appear at predefined places in the main window. This arrangement of the "workspace" is stored in the configuration file "Default EZ2-AFM.gui" or "Default EZ2-STM.gui" by default. The location of the configuration files on the hard-disk depends on the operating system you use. Functions for storing and retrieving the workspace are accessed via the menu "File" >> "Workspace".

"Save" saves the workspace to the currently selected workspace file.

"Save as..." saves the current arrangement of the panels under another name.

"Load" loads a previously saved workspace.

12.5.3: Entering values in the control panels

To change a parameter in any panel:

1. Activate the parameter by clicking it with the mouse pointer, or by selecting it with the "Tab" key.

2. In case of a drop-down menu selection list (e.g.: 

), change the selection using the mouse, or the up and down arrows on the keyboard. In case of a numerical value, use one of the following methods:

   - Use the up and down arrow keys on the keyboard to increase or decrease its value. The new value is automatically used after one second.
   - Click the arrow buttons  next to the parameter's value with the mouse pointer. The new value is automatically used after one second.
   - Enter the new value using the keyboard. The entered value is applied upon pressing the "Enter" or "Return" key, or by activating another input. The entered value is discarded upon pressing the "Esc" key. The unit prefix can be changed by typing one of the following keyboard keys:

f	= femto	space bar	= no prefix
p	= pico	k	= kilo
n	= nano	M (shift-m)	= mega
u	= micro	G (shift-g)	= giga
m	= milli	T (shift-t)	= tera

     Examples: if the basic unit is Volts, type "m" to change to millivolts, type the space bar for volts, type "u" for microvolts.

   Sometimes the program will change an entered parameter value to a slightly different value. This happens when the desired value is outside the digitization range of the easyScan 2 Controller, for example due to resolution or timing limits. In such cases, the desired value is automatically changed to the nearest possible value.

12.5.4: Storing and retrieving measurement parameters

All measurement parameters are stored in a configuration file with the extension ".par". When the easyScan 2 software is started, default values are loaded from a file that is selected in the Controller Configuration Dialog (*Section 13.5: The Controller Configuration dialog* (page 136)). Functions for storing and retrieving parameters are accessed via the menu "File" >> "Parameters".

"Save" saves the parameters to the currently selected parameter file. The name of this file is indicated in the status bar at the bottom of the main window.

"Save as..." saves the parameters under a new file name.

"Load" loads a previously saved parameter file.

IMPORTANT

When you have not loaded another file, "Save" will overwrite the original default parameter file with you current settings.

12.6: The User Interface dialog



The User Interface dialog is opened via the menu "Options" >> "Config User Interface...".

Program Skin

Select the look of the easyScan 2 software you are most comfortable with. All screenshots in this manual were made with the Windows XP skin.

User Interface Mode

Determines the number of parameters displayed in the various panels:

– **Easy level** Only those parameters that are absolutely necessary to do a measurement
– **Standard level** The commonly useful parameters
– **Advanced level** All available parameters

Options

Save workspace on exit
When active, the workspace settings are saved to the system registry when the software is exited (*Section 12.5.4: Storing and retrieving measurement parameters* (page 110))

Animated menu
When active, the opening of the menu is nicely animated.

CHAPTER 13:

Hardware-related settings

CHAPTER 13: Hardware-related settings

During normal operation of the microscope, changes have to be made to several hardware-related settings in the easyScan 2 software for the microscope to function properly. The Operating mode panel and the Z-Controller panel are used for this task. Other changes are generally only made when the hardware is changed. The settings defining the hardware configuration are distributed over several dialogs that are reached via the "Options" menu. All of the above panels and dialogs are discussed in this chapter.

13.1: The Operating Mode panel

The operating mode panel allows you to select the operating mode that you wish to use, and to set up several operating mode related parameters. The operating mode determines which signals are measured, and which signal is used to control the Z-position. To open the Operating mode panel, click  in the navigator.

The number of available modes depends on the Scan head and on the modules built into the easyScan 2 controller. The modules required to be able to use a certain operating mode are listed in *Table 13-1: Operating modes and required modules*. The modes can be divided into the static operating modes that control the Z-position using the Cantilever deflection, the dynamic operating modes that control the Z-position using the vibration amplitude, and the STM mode that controls the Z-position using the tunnelling current.

Operating mode	Required modules
STM	STM scan head
Static force	AFM Basic
Dynamic force	AFM Basic, AFM Dynamic
Phase contrast	AFM Basic, AFM Dynamic, AFM Mode Extension
Force Modulation	AFM Basic, AFM Dynamic, AFM Mode Extension
Spreading Resistance	AFM Basic, AFM Mode Extension

Table 13-1: Operating modes and required modules

The signals measured with each of the operating modes are listed in *Table 13-2: Operating modes and signals measured*. Note that the names of the signals can be changed in the "Scan Head Calibration" dialog.

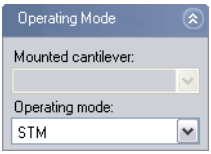
Operating mode	Signals measured
STM	Topography, Tip Current (User Inputs 1+2)
Static force	Topography, Cantilever deflection(, User Inputs 1+2)
Dynamic force	Topography, Vibration amplitude(, User Inputs 1+2)
Phase contrast	Topography, Vibration amplitude, Vibration phase(, User Inputs 1+2)
Force modulation	Topography, Cantilever deflection, Vibration amplitude(, User Inputs 1+2)
Spreading Resistance	Topography, Cantilever deflection, Tip current(, User Inputs 1+2)

Table 13-2: Operating modes and signals measured. The User Inputs are only available when they are enabled and the Signal Module A is installed.

13.1.1: STM mode

This mode is only available when an STM head is connected to the controller. In this case, it is the only available mode setting.

Operating mode (Easy, Standard, Advanced)



Mounted cantilever (Easy, Standard, Advanced)
Not available, this input is only used for AFM modes.

Operating mode (Easy, Standard, Advanced)
STM mode by default.

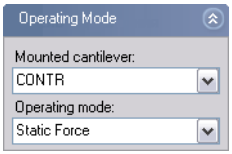
User Input/Output (Standard, Advanced)

See the description under Static Force mode.

13.1.2: Static Force mode

In the static force mode, the Operating Mode and User Input sections are available.

Operating Mode (Easy, Standard, Advanced)

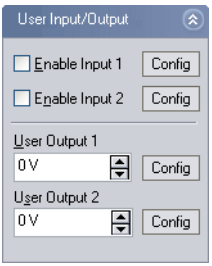


Mounted cantilever (Easy, Standard, Advanced)
The mounted cantilever type. The mounted cantilever type is used to automatically determine the search range in the dynamic operating modes, and to determine the correct calibration for the force set point in the static operating modes.

Operating mode (Easy, Standard, Advanced)
Changes the operating mode.

User Input/Output (Standard, Advanced)

Enable User Input1, 2

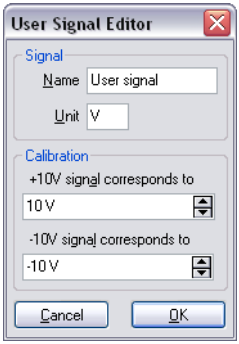


When active, the data from the User input (*Section 11.2: The Signal Modules* (page 97)) is measured and stored. Enabling the user inputs significantly increases the measurement file size.

User Output 1, 2
The output value of the user output.

Config...
Opens the User Signal Editor dialog.

13.1.3: The User Signal Editor



The User Signal Editor dialog is used for editing the calibration of the User Input/Output signals. It can be reached through the User Input/Output section of the Operating Mode Panel. The settings made in this dialog are stored in the Scan Head calibration file.

Signal

Name
The name of the user signal. This name is used throughout the software.

Unit
The base unit of the physical signal, without prefix (i.e. m, not nm or µm).

Calibration

The physical signal values that correspond to the maximum and minimum signal voltages should be entered here. Prefixes can be used here.

13.1.4: Dynamic Force mode

In addition to the same Operating mode and the User Input section as in the static operating mode, two sections of parameters may be available, depending on the user interface mode.

The dynamic force mode parameters can either be set manually or determined using an automatic search procedure. The automatic search starts with a coarse measurement of a cantilever resonance curve (*Figure 13-1: Determination of the vibration frequency*).Throughout this measurement, the cantilever is excited with a fixed amplitude, while the excitation frequency is varied. The resonance curve contains a measurement of the resulting cantilever vibration as a function of the excitation frequency. When the search is successful, the resonance curve contains a single peak at the free resonance frequency of the cantilever. Afterward, a second, fine-tuning search is performed in a 3 kHz frequency range around the resonance frequency detected in the coarse search.

The computer adjusts the value of Vibration frequency so that the cantilever vibration amplitude is reduced by the amount set in "Amplitude reduction" in the Freq. Peak Search section.

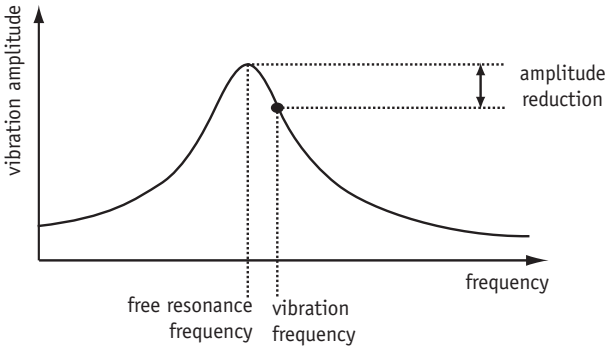
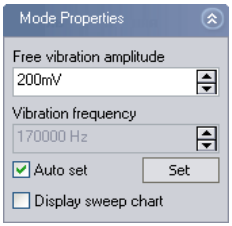


Figure 13-1: Determination of the vibration frequency

Mode Properties (Easy, Standard, Advanced)



Free vibration amplitude (Easy, Standard, Advanced)
The desired reference amplitude of the cantilever vibration. The cantilever vibrates at this amplitude when it is far away from the sample. The excitation strength is adjusted so that this vibration amplitude is reached.

Vibration frequency (Standard, Advanced)
The frequency at which the cantilever vibrates during the measurement. This frequency can be set automatically as described at the start of this section. When "Auto set" is enabled, the Vibration frequency is automatically set each time an approach is started. When "Auto set" is disabled, the frequency can be set manually, either by directly changing its value in the control box, or by using the Vibration Frequency Determination dialog (see *Section 13.1.8: The Vibration Frequency Determination dialog* (page 121) for details). The Vibration Frequency Determination dialog is opened by clicking Set.

Display sweep chart (Standard, Advanced)
When active, the results of the vibration frequency search measurements are transferred to measurement documents and displayed in new windows.

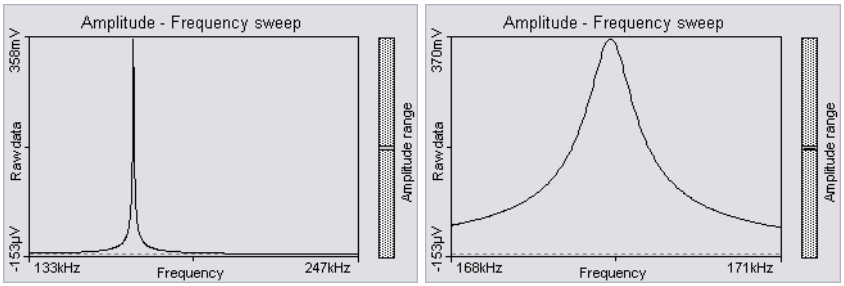


Figure 13-2: Cantilever resonance curve. (left) coarse search, (right) fine-tuning search

13.1.5: Phase Contrast mode

In addition to the parameters in the Dynamic Force operating mode, the Reference Phase is available in the Standard and Advanced user interface modes.

Reference Phase (Standard, Advanced)
The reference phase for the detected cantilever vibration. Changing the reference phase changes the offset of the phase signal. The phase reference can be automatically set so that the phase signal is zero. When "Auto set" is enabled the phase reference is automatically set after finishing the approach. Clicking Set starts the automatic setting immediately.

13.1.6: Force Modulation mode

In addition to the parameters in the Static Force operating mode, two additional parameters are available:

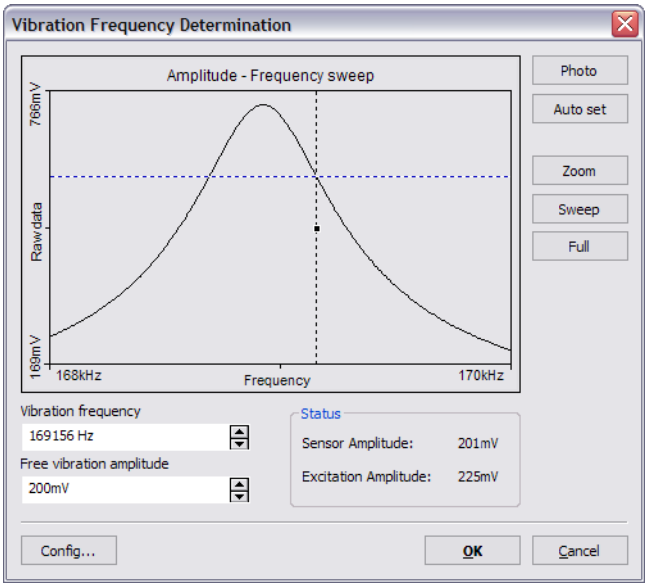
Excitation amplitude
The amplitude of the sensor excitation during a force modulation mode measurement.

Excitation frequency
The frequency of the sensor excitation during a force modulation mode measurement. Clicking Set starts a measurement of the cantilever resonance curve, that helps you to select the excitation frequency. The settings for this measurement are the same as those for the Dynamic Force measurement.

13.1.7: Spreading Resistance mode

The operating mode panel for the Spreading Resistance mode is the same as that for Static Force operating mode.

13.1.8: The Vibration Frequency Determination dialog



The Vibration Frequency Determination dialog is opened by clicking the vibration frequency "Set" button in the Mode Properties section of the Operating Mode Panel (see *Section 13.1.4: Dynamic Force mode* (page 118), and provides several ways to find and change the vibration frequency in any of the dynamic measurement modes.

When first opened, an automatic frequency peak search is conducted using the parameters that are defined on basis of the cantilever type that is currently selected. This automatic frequency peak search consists of two frequency sweeps: one coarse and one fine sweep. The results of the frequency sweeps are displayed sequentially inside the graphical area of the Vibration Frequency Determination dialog. The vibration frequency that is selected is indicated by a vertical dashed line in the sweep chart. A horizontal dashed line indicates the sensor amplitude corresponding to the currently selected vibration frequency.

Vibration frequency
Shows the frequency that will be used as vibration frequency. The value of this frequency can be changed manually by typing in the desired value, by using the arrow keys beside the parameter field, or by dragging the vibration frequency line (dotted vertical line in the sweep chart area of the dialog box) to a different location. The latter can be done by clicking and holding the line's handle (small black box in the center of the line) and moving it around. Any changes to the vibration frequency immediately update the measured sensor amplitude and corresponding horizontal dashed line in the sweep chart. To use the currently shown frequency as the new vibration frequency, leave the dialog with the "OK" button.

Free vibration amplitude
While in the Vibration Frequency Determination dialog, the free vibration amplitude (normally set in the corresponding field inside the Operating Mode panel) can be changed via this field. When changed, a new sweep is immediately performed and its results displayed.

Status
This area shows the measured free vibration amplitude (as measured by the photodiode sensor in mV) and the excitation amplitude (voltage of the shaker piezo input signal) required to obtain the selected free vibration amplitude at the current vibration frequency.

Config...
Used to open the Vibration Frequency Search Parameters dialog. In this dialog, the parameter defining the automatic vibration frequency search can be changed (see *Section 13.1.9: The Vibration Frequency Search Parameters dialog* for details).

OK
Accept the results of the automatic vibration frequency determination, or the changes made to it manually.

Cancel
Rejects the results of the automatic vibration frequency determination, or the changes made to it manually.

Photo
Takes a snapshot of the currently displayed sweep chart and displays it in a new measurement window.

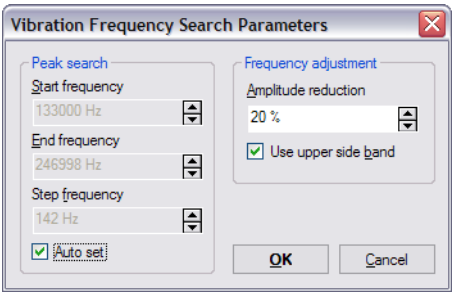
Auto set
Performs an automatic vibration frequency determination according to the parameters set in the Vibration Frequency Search Parameters dialog. This procedure is identical to the one performed upon opening of the Vibration Frequency Determination dialog, but you may choose to run it again if you moved the vibration frequency manually, if you changed the vibration frequency search parameters (after pressing the "Config..." button), or if you changed the magnification of the sweep chart by using the "Zoom" or "Full" buttons.

Zoom
Zooms in on the current vibration frequency position (determined by the automatic vibration frequency determination, or changed manually). A new frequency sweep with a smaller frequency range is performed to display the results. No new vibration frequency is determined. "Zoom" can be pressed several times to reach higher zoom levels.

Sweep
Repeats the last frequency sweep (the one that is currently displayed in the graphical area of the Vibration Frequency Determination dialog, so that you may check resonance peak stability. No new vibration frequency is determined.

Full
Performs a frequency sweep over the full frequency range, as set by the vibration frequency search parameters. No new vibration frequency is determined.

13.1.9: The Vibration Frequency Search Parameters dialog



The parameters for the automatic vibration frequency search are set here.

Start frequency (Standard, Advanced)
The start frequency for the coarse search

End frequency (Standard, Advanced)
The end frequency for the coarse search

Step frequency (Standard, Advanced)
The difference between two frequency points at which the cantilever vibration amplitude is measured during the coarse search. If the increment is small, the peak search is very accurate, but takes more time. If the increment is large, the search takes less time. When it is too large, however, there is a risk that the resonance frequency will not be found.

Auto set (Standard, Advanced)
When active, the range and frequency increment are automatically set to suitable values for the currently selected cantilever type, based on the resonance frequency and Q-factor listed in the Cantilever Browser dialog (see *Section 13.3.1: The Cantilever Browser dialog* (page 128) for details).

Amplitude reduction (Standard, Advanced)
Indirectly determines the "Vibration Frequency" in the "Auto set" mode: The computer adjusts the Vibration frequency so that the cantilever vibration amplitude is "Amplitude reduction" percent smaller than the vibration amplitude at the resonance frequency.

Use upper sideband (Advanced)
When active, the vibration frequency is set to a frequency higher than the resonance frequency. Otherwise, the vibration frequency is set lower.

13.2: The Z-Controller panel

The tip–sample interaction is normally kept constant using the Z-Controller. The Z-Controller is a PI(D) controller as is shown in *Figure 13-3: Z-Controller*. The settings of this controller are set in the Z-Controller panel. To open the Z-Controller panel, click  in the Navigator.

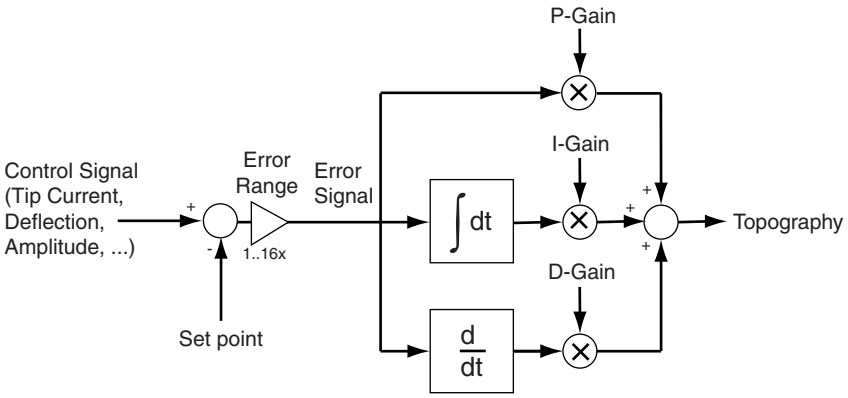
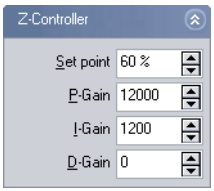


Figure 13-3: Z-Controller

Z-Controller (Easy, Standard, Advanced)



Set point (Easy, Standard, Advanced)
The working point for the Z-Controller. Depending on the operating mode, this is the tunneling current (STM mode), cantilever deflection (static force

mode) or relative cantilever vibration amplitude (dynamic force mode). In the latter case, the set amplitude is relative to the operating amplitude, set in the Operating mode panel. For example, when a set point of 70% is used, the Z-Controller will move the tip closer to the sample until the vibration amplitude has decreased to 70% of the vibration amplitude far away from the sample.

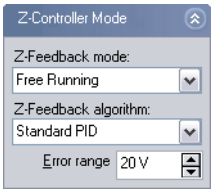
Loop Gain (Easy)
The speed of the Z-Controller. If the gain is too low, the Z-Controller will not follow the surface fast enough. Thus, the image will not be as sharp as it could be. If the gain is too high, the Z-Controller will overshoot and may start to oscillate. Thus, the image will contain many measurement artifacts.

P-Gain (Standard, Advanced)
The strength of the Z-Controller reaction that is proportional to the error signal. Increasing the P-Gain decreases the error signal.

I-Gain (Standard, Advanced):
The strength of the Z-Controller reaction that is proportional to the integral of the error signal. Increasing the I-Gain decreases the error signal over time. It is the least sensitive to noise, and usually the dominant contributor to the topography measurement.

D-Gain (Advanced)
The strength of the Z-Controller reaction that is proportional to the derivative of the error signal. Increasing the D-Gain decreases fast changes in the error signal, but also amplifies high frequency noise.

Z-Controller Mode (Advanced)



Z-Feedback Mode

The following modes are available:

– **Free Running** The Z-Controller is active.

– **Freeze Position** The Z-Controller is not active, the scanner remains in its current Z-position.

– **Stop and Clear** The Z-Controller is not active, the scanner is moved to the "Ref. Z Plane", set in the Imaging Panel.

The Probe Status Light (see *Figure 1-4: The easyScan 2 controller* (page 17)) will blink green as long as the Z-Controller is deactivated.

IMPORTANT

The tip may be damaged when the Z-Controller is not active during scanning. This will happen when Ref. Z Plane is much lower than the current position of the tip, or when the scan range contains large height differences.

Z-Feedback algorithm

The following algorithms are available:

– **Standard PID** A standard PID controller is used for Z-Feedback.

– **Adaptive PID** A standard PID controller is used for Z-feedback. In addition, the bandwidth of the Topography measurement is adapted to the number of measured points per second.

The adaptive PID controller reduces noise in the measurement. However, topography changes that happen faster than the time between two measured points are also lost. This makes it more difficult to detect vibrations due to instability of the feedback loop. These vibrations remain visible in the Current, Amplitude, or Deflection signal. Therefore, always monitor these signals when optimizing Z-Controller settings, especially when using the Adaptive PID.

Error Range (Advanced)

The range of the error signal used to control the Z-Position. The error signal is the difference between the signal used for topography feedback and the current set point. When the value of "Error Range" is reduced, the resolution of the error signal is increased.

Tip Properties (Standard, Advanced)

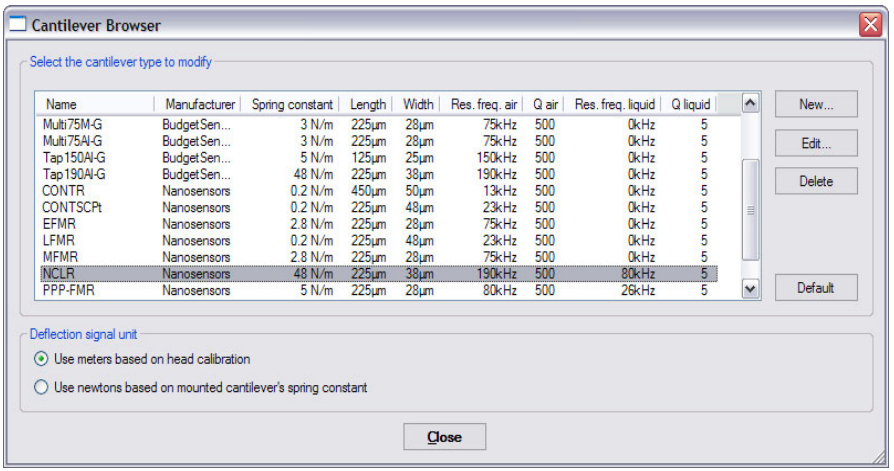


Tip Voltage (Standard, Advanced)
The potential to be applied to the tip. The voltage that can be used lies between –10V and +10V. In the STM, the sample is automatically connected to the ground of the instrument. In the AFM, the sample has to be electrically connected to the instrument chassis ground for accurate measurements.

13.3: Cantilever types configuration

The cantilever types that you can select from in the Operating Mode Panel are configured using two dialogs: The cantilever browser, and the cantilever editor dialog. The cantilever types configuration is stored in a file called "cantilever.ini", located in the Local Settings directory of the user logged on to the computer.

13.3.1: The Cantilever Browser dialog



The cantilever browser dialog is opened via the menu “Options” >> “Config Cantilever Types...”. The cantilever browser allows creating, editing and deleting of cantilever types.

Select the cantilever type to modify

Select the cantilever type you wish to modify and click on any of the following buttons:

New...
Opens the Cantilever Editor dialog for a new cantilever type. You can create new cantilever types that are not defined in the default configuration.

Edit...
Opens the Cantilever Editor dialog to modify the currently selected cantilever type.

Delete
Deletes the currently selected cantilever type.

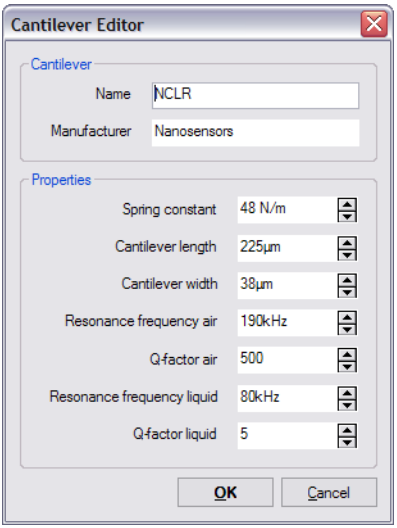
Default
Sets all cantilevers types back to their default factory settings. All changes will be lost.

Deflection signal unit

Two cantilever deflection unit styles are available for all static force operating modes:

– **Use meters based on head calibration** The deflection of the cantilever is displayed in meters in all charts. This is the default setting.
– **Use Newtons based on mounted cantilever's spring constant** The deflection of the cantilever is displayed in Newtons in all charts. This is particularly useful for recording Force-Distance curves with the Spectroscopy Window.

13.3.2: The Cantilever Editor dialog



Allows the creation of new cantilever types that are not defined in the default configuration, and editing of existing cantilever types. Please note that the easyScan 2 Scan Head can only be used with cantilevers possessing the following cantilever properties:

- The sensor chip must have grooves that fit onto the alignment chip.
- The cantilever should have a nominal length of 225 µm or more, and a top width of 40 µm or more (please distinguish between mean width specified by most manufacturers and the actual top width of trapezoid-shaped cantilevers).
- The back of the cantilever must have a coating that reflects infrared light. Uncoated cantilevers transmit much of the infrared light of the cantilever deflection detection system.

In the Cantilever Editor dialog, the following properties of a cantilever type can be entered:

Name of cantilever
The name of the cantilever type. This name appears in the cantilever browser and the Cantilever type drop-down menu in the Operating Mode Panel.

Manufacturer
The name of the cantilever manufacturer. This name appears in the cantilever browser and the Cantilever type drop-down menu in the Operating Mode Panel.

Spring constant
The nominal spring constant of this cantilever type. This value is used to calculate the correct force Set point in the operating modes that use the static force for Z-Control (*Section 13.1.2: Static Force mode* (page 116)).

Cantilever length
The nominal length of this cantilever type (currently not used).

Cantilever width
The mean width of this cantilever type (currently not used).

Resonance frequency air
The nominal resonance frequency of the cantilever type in air. This frequency is used for calculation of the automatic resonance frequency search range (*Section 13.1.4: Dynamic Force mode* (page 118)).

Q-factor air
The apparent quality factor of the cantilever in air. The quality factor of a resonance peak is a measure of peak width. The higher the number, the sharper the peak. By default, this number is 500 in air, corresponding to a sharp peak. The quality factor is used for calculation of the automatic resonance frequency search range (*Section 13.1.4: Dynamic Force mode* (page 118)).

Resonance frequency liquid
The nominal resonance frequency of the cantilever type in liquid (may vary depending on buffer composition, but defaults roughly correspond to the cantilever behavior in water). This frequency is used for calculation of the automatic resonance frequency search range (*Section 13.1.4: Dynamic Force mode* (page 118)).

Q-factor air
The apparent quality factor of the cantilever in liquid. The quality factor of a resonance peak is a measure of peak width. The higher the number, the sharper the peak. By default, this number is 5 in liquid, corresponding to a wide peak. The quality factor is used for calculation of the automatic resonance frequency search range (*Section 13.1.4: Dynamic Force mode* (page 118)).

13.4: Scan Head configuration

The Scan Head configuration is used to store all calibration values specific to a certain Scan Head. The configuration of each Scan Head is stored in a file with the extension ".hed". This file is copied from the software installation CD on installation of the instrument. When you change the Scan Head, you should also load the correct configuration file.

13.4.1: The Scan Head Selector dialog

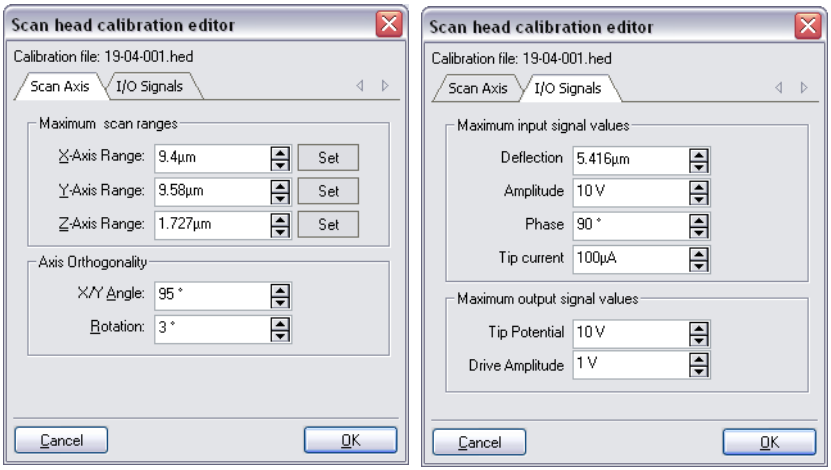
The Scan Head selector dialog is opened via the menu "Options" >> "Config Scan Head...".

Load...
Loads a different Scan Head configuration file.

Save as...
Saves the current Scan Head configuration under another name.

Edit...
Edit the currently loaded Scan Head configuration using the Scan Head calibration dialog. Always save a backup of the Scan Head configuration by clicking 'Save As...'.

13.4.2: The Scan Head Calibration Editor dialog



In this window the calibration of all standard Inputs and Outputs can be configured individually for a particular Scan Head. The configuration of the User inputs and outputs is located in a different dialog (*Section 13.1.3: The User Signal Editor* (page 117)).

IMPORTANT

Changes to these settings should be performed with great care. False settings can lead to false interpretation of the data and incorrect operation of the controller.

Scan Axis, Maximum scan ranges

X/Y/Z-Axis Range
The calibration values of each of the scanner axes. The calibration values are given as the maximum motion range of the scanner (when Overscan is set to 0%).

Set
Opens the scan axis correction dialog (see next section).

Scan Axis, Axis Orthogonality

The X- and Y-Axes of the scanner are generally not perfectly orthogonal, and their orientation with respect to the AFM housing may vary. The easyScan 2 software corrects these errors by adding/subtracting some of the X scanner command signal to the Y scanner command signal and vice versa.

X/Y Angle
The angle between then the X- and Y-axis of the scanner hardware. The software uses this value to correct the scan command signals such that the scan axes are orthogonal.

Rotation
The angle between the X-axis of the scanner and the X-axis of the microscope body (*Figure 10-3: Scanner coordinate system* (page 99)). The software uses this value to correct the scan command signals in such a way that the scan axis is parallel to the X-axis of the microscope body.

I/O Signals, Maximum input signal values

Deflection
The calibration of the cantilever deflection signal.

Amplitude
The calibration value of the cantilever vibration amplitude signal.

Phase
The calibration value of the cantilever vibration phase shift signal.

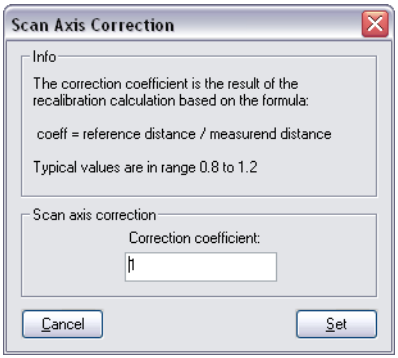
Tip current
The calibration value of the internal Tip current measurement

I/O Signals, Maximum output signal values

Tip Potential
The calibration value of the Tip voltage setting.

Drive Amplitude
The calibration value of the Amplitude of the signal that is used to excite the cantilever. The Drive Amplitude signal is only displayed in the Data Info Panel.

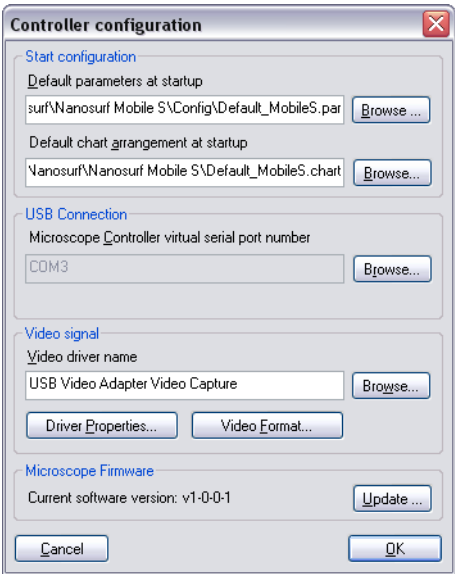
13.4.3: The Scan Axis Correction dialog



This dialog can be used to multiply the scan axis calibration factor by a correction coefficient that has been determined by evaluating the measurement of a calibration grid, for example using SPIP/Nanosurf Analysis.

Scan axis correction
The Scan range is multiplied with this number when the “Set” Button is clicked.

13.5: The Controller Configuration dialog



The Controller configuration dialog is opened via the menu “Options” >> “Config Controller...”. On a correctly configured system, it should not be necessary to change the settings in this dialog, except for the start-up parameters and chart arrangement file configuration.

Start configuration

The parameter and chart arrangement files that are loaded when the software starts (*Section 12.5.4: Storing and retrieving measurement parameters* (page 110)).

USB Connection

The easyScan 2 controller uses a virtual serial port that is connected to the USB port. The number of this virtual serial port should be the same as the one shown in your the windows device manager dialog.

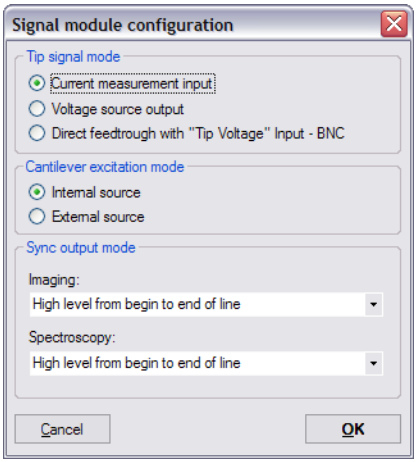
Video Signal

Allows configuration of the internal video capture device of the easyScan 2 controller. The default configuration should normally not be changed. This feature is only available when the video camera is installed.

Microscope Firmware

Click the “Update” button to install firmware updates that you receive from Nanosurf support.

13.6: The Signal Module Configuration dialog



When the Signal Module A is installed, the Signal Module Configuration dialog allows several parameters to be configured:

Tip Signal Mode

The following settings are available:

– **Current measurement input** Sets the tip signal to the input current measurement level.

– **Voltage source output** Sets the tip signal to the measured output voltage.

– **Direct feedthrough with "Tip Voltage" Input-BNC** Establishes a direct connection between the "Tip-Voltage" Input BNC connector and the cantilever.

All of these choices are described schematically in *Figure 13-4: Tip Signal Mode schematic*.

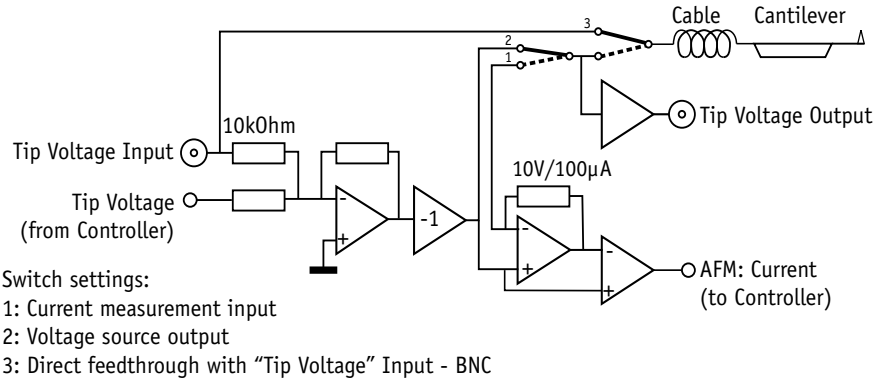


Figure 13-4: Tip Signal Mode schematic. Describes the electronics behind the three Tip Signal modes available.

Cantilever Excitation Mode

The following options are available:

– **Internal source** Cantilever excitation is controlled by the easyScan 2 controller itself.

– **External source** Cantilever excitation is controlled by an external source.

Sync Output Mode

Allows configuration of the output that can be used to synchronize external equipment with the easyScan 2 controller. Different settings can be applied to Imaging and Spectroscopy modes. These features can also be controlled through the scripting interface. For more information, refer to the Script Programmers Manual, topic "Object Reference" >> "Class Scan" >> "SyncOutMode" and "Object Reference" >> "Class Spec" >> "SyncOutMode".

13.7: The Edit Access Codes dialog



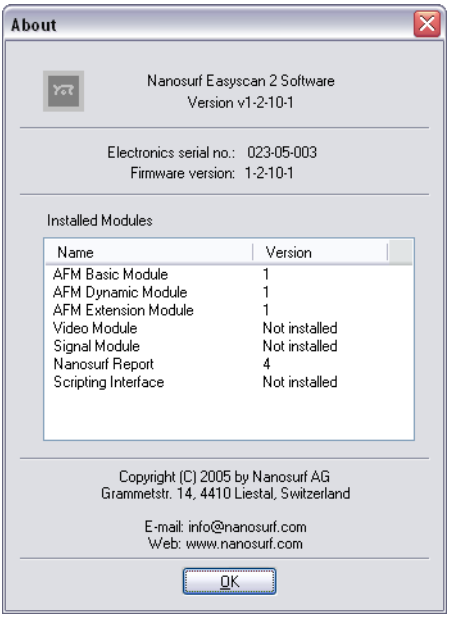
The Edit Access Codes Dialog is used to enter the access code for software modules, such as the Scripting Interface and the Lithography Option. The dialog is accessed via the menu entry “Options” >> “Config Access Codes...”

13.8: Simulate Microscope

Check or uncheck the menu item “Options” >> “Simulate Microscope” to enter or exit the simulation mode. Once the simulation mode is active, the first field in the status bar of the easyScan 2 software displays the text “Simulation”, otherwise this field displays the text “Online”.

In the simulation, many functions of the microscope are performed on a mathematically generated surface. Thus, the software functionality and working methods of the microscope can be practised.

13.9: The About dialog



The About dialog displays information that may be useful for diagnostics when you have problems with your instrument. To open the About dialog:

➔ Select the menu entry “?” >> “About...”.

The about dialog contains the following information:

- The version number of the control software
- The serial number of the controller (when the microscope simulation is active, the serial number “000-00-000” is displayed).
- The version number of the firmware that is running on the controller
- The version number of the built-in modules
- Contact information for getting more support.

CHAPTER 14:

Positioning

CHAPTER 14: Positioning



The Positioning window contains all the software tools for positioning the tip with respect to the sample:

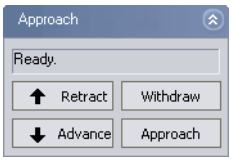
- The Approach panel
- The Video panel (only for AFM systems with Video Module)
- The Video display (only for AFM systems with Video Module)

Click  in the Navigator to open the Positioning window.

14.1: The Approach panel

The motor for the tip–sample approach is operated using the “Approach Panel”.

Approach (Easy, Standard, Advanced)



Status
Displays the current status of the approach stage.

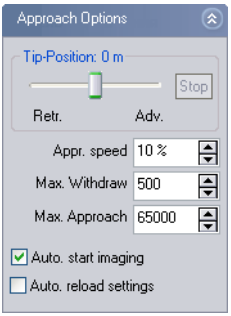
Retract
Increases the tip–sample distance at maximum speed until the button is released.

Advance
Decreases the tip–sample distance at maximum speed until the button is released.

Withdraw
Increases the tip–sample distance with the settings given in the Approach Options.

Approach
Starts the automatic approach. During the automatic approach, the tip–sample distance is decreased until the Set point, set in the Z-Controller panel, is reached, or until the maximum approach time is reached.

Approach Options (Standard, Advanced)



Tip-Position (Advanced)
Determines the Z-Position of the scanner when the approach motor stops. When the Tip-Position is changed when the tip is already approached to the sample, the motor will move the approach stage so, that the Z-Position of the tip becomes equal to the set Z-Position. When a high resolution (2 µm Z-Range) scanner is used, the Tip-Position before the approach is set to +500 nm

Advanced by default. This compensates for the residual motion of the approach stage that occurs after the approach motor has stopped.

CAUTION

Changing the Z-Position when the tip is approached to the sample may cause tip damage when using high resolution scanners. This can be due to play in the approach stage, which is caused by a change in the initial load of the approach stage bearings. Contact your local Nanosurf representative if this seems to be the case.

The Tip-Position setting can for example be useful when a sample is mainly a large flat surface with some deep holes in it. In this case proceed as follows:

1. Ideally, first make sure that the center position of the Scan range is outside a hole.

   When the Scanner is idle (such as during approach), the tip is always brought to the center position of the scan range.

2. Set Tip-Position to about 80% of the maximum value.

3. Click Approach

The Tip-Position setting cannot be used with STM scan heads, which is due to the different approach motor used in the STM.

Stop button
Stop the adjustment of the height.

Appr. speed (Standard, Advanced)
The speed of the motor during the automatic approach and withdraw. When an STM scan head is used, the Approach speed changes the Step size of the approach motor, the step frequency is determined by the speed of the feedback loop.

CAUTION

If the approach is too fast, the tip or the sample surface can be damaged. On the other hand, the motor will not move when Appr. speed is too small.

max Withdraw (Standard, Advanced)
The maximum withdraw duration after clicking Withdraw.

max Approach (Advanced)
The maximum approach duration after clicking Approach.

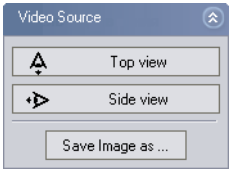
Auto. start imaging (Standard, Advanced)
When selected, the system automatically starts imaging after a successful approach. Scanning automatically stops the approach motor is moved.

Auto. reload settings (Advanced)
When selected, the software reloads the default startup parameter file for each approach (*Section 13.5: The Controller Configuration dialog* (page 136)).

14.2: The Video panel

The video panel controls the video display in the Positioning window (only for AFM systems). Changing these settings only has an effect when a Video camera is fitted on your system.

Video source



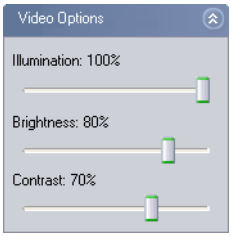
The video source section determines which video signal is currently displayed.

Top view
Switches the video display to the top view.

Side view
Switches the video to the side view.

Save Image as ...
Saves the currently displayed image to a JPEG file that is selected using a "Save file as..." dialog.

Video Options



The Video Options section determines how the video signal is displayed. There are separate sets of options for the side and the top view.

Illumination
The intensity of the sample illumination on the Scan Head.

Brightness
The brightness of the video display

Contrast
The contrast of the video display

CHAPTER 15:

Imaging

CHAPTER 15: Imaging

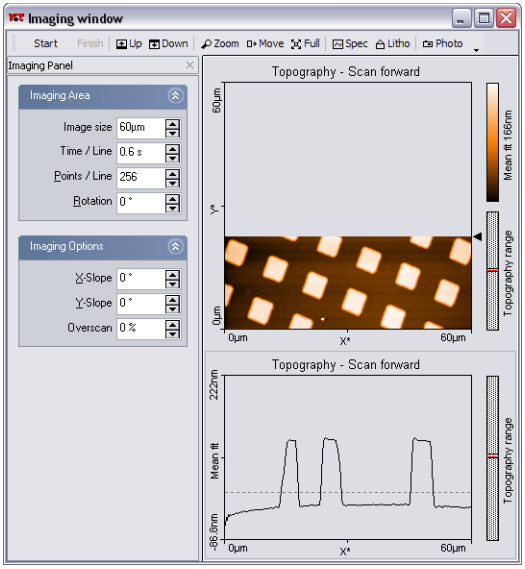


Figure 15-1: The imaging window

Imaging measurements of the sample are controlled using the Imaging window. The Imaging window can be opened by clicking  in the navigator. The Imaging window contains the Imaging bar, with commands that control the imaging processes, and the Imaging panel, with parameters that determine how the imaging is done.

The Imaging window also contains a number of charts that display the data from the ongoing measurement. The imaging window can display as many charts as the size of the window can accommodate. By default, two charts are displayed, a Line graph, and a Color map of the sample Topography. For more information on adding and changing charts (*Chapter 18: Viewing measurements* (page 185)).

15.1: The Imaging bar

Start / Stop

Start starts a measurement and then changes to Stop. Clicking Stop aborts the measurement as soon as the current scan line is finished.

Finish

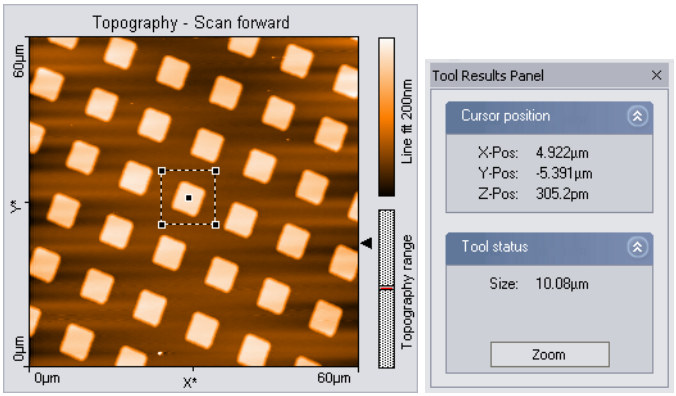
After clicking Finish the measurement stops when the current measurement has finished.

Up / Down

Starts a single measurement or changes the scanning direction of the measurement in progress. With Up the image is scanned from the bottom to top, with Down it is scanned from the top to the bottom. If a measurement has been started using Up or Down the measurement stops automatically after one full image.

Zoom

Selects an area that is to be measured in more detail. The size and area of the area is displayed in the Tool Results panel.



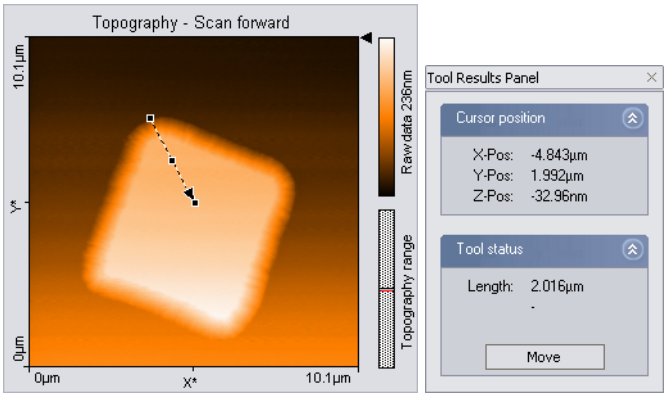
One corner of the zoomed area is defined by the mouse cursor position where the left mouse button is clicked, the opposite corner by the position where the button is released. When the mouse is not moved between clicking and releasing, an area is defined that has a size of 33% of the current measurement, and centered on the clicked location. Once an area is defined, it can be resized by dragging one of its corners, and moved to the desired position by dragging its center point.

A double click with the left mouse button in the chart, or clicking the “Zoom” button in the Tool Results panel, modifies the parameters Scan range, X-, Y-

Offset in the Imaging window accordingly. When the zoom function is active it can be aborted by clicking Full again.

Move

Moves the position of the imaged area. An interesting corner can thus be moved to the center of the measurement. The Tool Results panel numerically displays the change in position.



The change in the position is indicated by an arrow. The start of the arrow is defined by the mouse cursor position where the left mouse button is clicked, the end of the arrow by the position where the button is released. When the mouse is not moved between clicking and releasing, an arrow ending in the center of the measurement is drawn. The direction of the arrow can be adjusted by dragging its end markers. It can be moved by dragging the center marker.

The image is moved by double clicking, or clicking the "Move" button in the Tool Results panel. The move function can be aborted by clicking Move again.

Full

Returns the parameters Scan range to the largest possible values, and "X-Offset" and "Y-Offset" to zero.

Spec

Transfers the currently measured data to the spectroscopy window. If a measurement is in progress, it is interrupted. It is advisable to use Finish to first complete the measurement before starting the spectroscopy measurement.

Litho

Transfers the currently measured data to the lithography window. If a measurement is in progress, it is interrupted. It is advisable to use Finish to first complete the measurement before starting the spectroscopy measurement.

Photo

Captures the measurement currently displayed in the "Imaging window" in a measurement document.

If Photo is clicked when a scan is in progress, a new measurement document is generated each time a measurement is finished. The capture process is cancelled by clicking Photo a second time.

To capture an image without waiting for the scan to be completed, stop the scanning by clicking Stop. The image can then be captured immediately by clicking Photo.

The measurement documents are labelled automatically with increasing numbers (i.e. Image1, Image2,...). When leaving the program you will be asked if you want to save the unsaved measurement documents.

15.2: The Imaging panel

The imaging settings use two coordinate systems: The Scanner coordinate system and the Measurement image coordinate system. To separate the two systems, the image axes are denoted by an asterisk (i.e. X*, Y*). The relation between the two coordinate systems is determined by various parameters in the imaging panel. The effect of these parameters is illustrated in *Figure 15-2: Coordinate systems*.

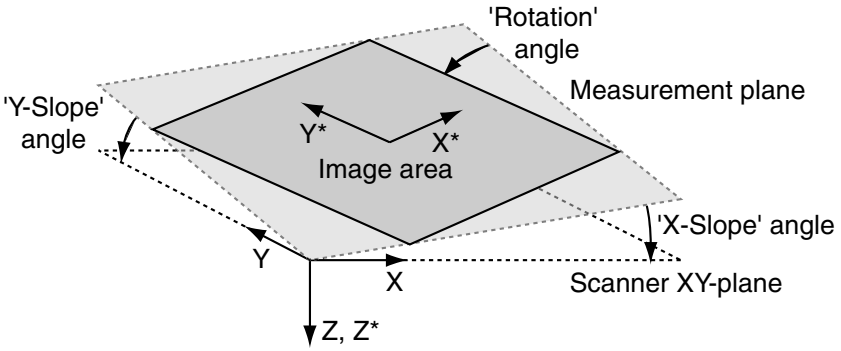


Figure 15-2: Coordinate systems

Imaging Area (Easy, Standard, Advanced)

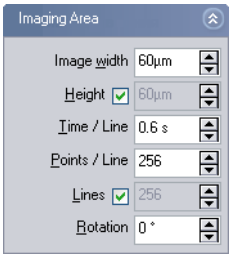


Image size (Easy, Standard)
The image size in both the X* and Y* direction. The size is doubled or halved when using ⇳.

Image width (Advanced)
The image size in X* direction.

Height (Advanced)
The image size in Y* direction. When the Check-box is active, the image Height is always identical to the Image width.

Points / Line (Easy, Standard, Advanced)
The number of measured data points per line.

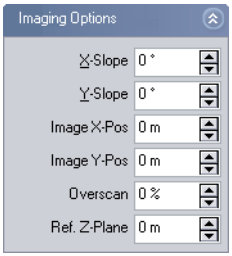
Lines (Advanced)
The number of measured data lines in an image. When the Check-box is active, the number of Lines is always equal to the number of Points / Line. In the easy and standard user interface mode, the number of Lines is always equal to the number of Points / Line.

Time / Line (Easy, Standard, Advanced)
The time needed to acquire a data line. The time needed for the entire image is approximately:

$$\textit{Image time} = \textit{'Time / Line'} \cdot \textit{'Lines / Frame'} \cdot 2$$

Rotation (Easy, Standard, Advanced)
The angle between the X-direction of the scanner and the X* direction of the measurement (*Figure 15-2: Coordinate systems*).

Imaging Options (Standard, Advanced)



The reference plane for the image can be aligned to the surface of the sample using the slope parameters (*Figure 15-2: Coordinate systems*).

X-Slope (Standard, Advanced)
A positive value rotates the image plane around the Y-axis counterclockwise.

Y-Slope (Standard, Advanced)
A positive value rotates the image plane around the X-axis counter-clockwise.

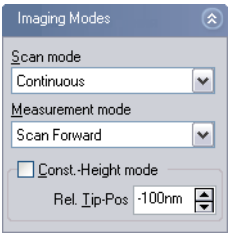
The center position of the measured area can be changed by typing its position as well as by using the Move tool in the imaging bar. The zero position is the center position of the scanner.

Image X-Pos, Y-Pos (Advanced)
The center position of the measured area.

Overscan (Standard, Advanced)
The amount by which the scan range of each line is made larger than the measurement range, relative to the image width. Thus edge effects, caused by the reversal of the scanning motion, are not displayed in the measurement. Disadvantages of using Overscan are that the maximum scan range is reduced, the tip moves slightly faster over the sample with the same "Time/Line" setting, and the tip may hit large features outside the measured image. The value of "Overscan" determines how much the scan range is increased relative to the Image width.

Ref. Z-Plane (Advanced)
The height of the reference plane. This height reference is used when the Z-Controller output is cleared, and when the Z-position is not modulated relative to the current surface position during spectroscopy measurements.

Imaging Modes (Advanced)



Scan mode
The Y* direction in which the data is acquired and displayed:
– **Continuous** the acquisition direction is reversed after each scan: from bottom to top and vice versa
– **Cont.Up** from bottom to top
– **Cont.Down** from top to bottom

Operating mode
The X* direction in which the data is acquired and stored:
– **Forward** during forward scan only (left to right in the image)

– **Backward** during backward scan only (right to left in the image)
– **Forw.&Backw.** during both forward and backward scan

Const.-Height mode
When the Constant Height Imaging mode is enabled, the Z-Controller is turned off during the scan (as a consequence, the Probe Status light will blink green). Instead, the scanner scans along a straight line, that should be parallel to the surface. The slope of the line is defined by the X- and Y-Slope parameters in the Imaging Options section of the Imaging Panel. These parameters should be set as described in *Section 5.3: Adjusting the measurement plane* (page 57). The height of the line is determined at the start of each scan line: First the Z-Controller is turned on. Once the tip position is stable, the Z-Controller is turned off and the tip is moved away from the sample by the distance set by the parameter Rel. Tip-Pos.

The Constant Height Imaging mode is mainly useful for EFM and MFM measurements. For more information on how to do Magnetic Force Microscopy, refer to technical note *TN00031 Magnetic Force Microscopy*, which can be downloaded from the support section of the Nanosurf web site at *www.nanosurf.com*.

Rel. Tip-Pos
The distance by which the Tip is moved towards the sample from the position that corresponds to the set point. A negative setting will move the tip away from the sample.

Run Button
Starts the currently loaded script. If there is an error in the script, a dialog box will appear.

CHAPTER 16:

Spectroscopy

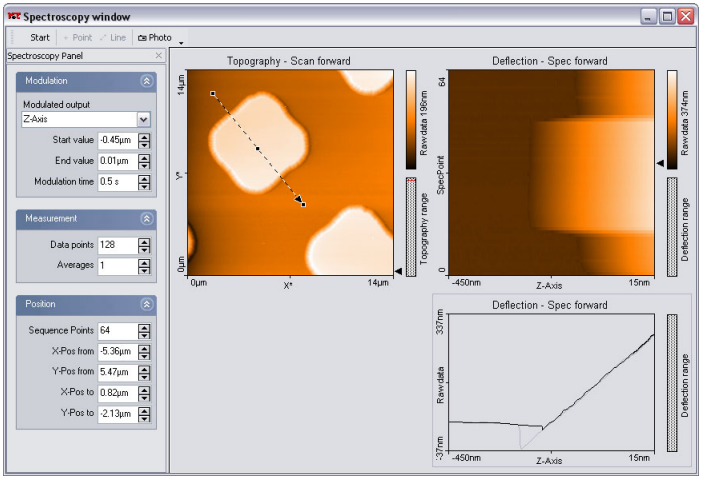


Figure 16-1: Spectroscopy window

In a spectroscopic measurement, the input channels are measured as a function of a modulated parameter. This modulated parameter can be the Z-distance to the sample, the tip voltage, or a User output channel (when Signal Module A is installed). Note that you must electrically connect the sample to the ground connector on the easyScan 2 STM Scan Head to apply a tip–sample voltage difference. The measured parameter can be any available input channel. Examples of a spectroscopic measurements are force/distance curves in the AFM static force mode, amplitude/voltage curves in the AFM dynamic mode, or current/voltage curves with the STM.

The accuracy of the spectroscopic measurements can be increased by averaging the measurement results of several consecutive modulations. A spectroscopic measurement sequence consists of a number of spectroscopic measurements of the same type, measured along a user defined line in the XY-plane. A point measurement is made if the number of points is one. The measurement sequence is carried out as follows:

1. Move the tip to the start of the line with active Z-control.
2. Switch off the Z-Controller.

3. Record a spectroscopic measurement.
4. Turn on the Z-Controller again.
5. Move the tip to the next point on the line in the XY-plane.

Steps 2–5 are repeated for all points on the line.

Spectroscopic measurement sequences are controlled using the Spectroscopy window. The Spectroscopy window can either be opened by clicking  in the navigator, or by clicking Spec in the Imaging bar. When the Spectroscopy window is activated from the Imaging bar, the currently measured image is transferred to the Spectroscopy window.

The Spectroscopy window contains the Spectroscopy bar, with commands that control the spectroscopy processes, and the Spectroscopy panel, with parameters that determine how the spectroscopy measurement is done.

The Spectroscopy window also contains a number of charts that display the data from a previous imaging measurement and the data from the ongoing spectroscopic measurement. The Spectroscopy window can display as many charts as the size of the window can accommodate. It is recommended to display at least two charts, one a Color map of a previous Topography measurement of the area where the spectroscopy measurement is performed, and one a Dual Line graph of the current spectroscopy measurement. For more information on adding and changing charts (*Chapter 18: Viewing measurements* (page 185)).

16.1: The Spectroscopy bar

Start / Stop

Start starts a spectroscopy measurement sequence and then changes to Stop until the measurement sequence is finished. Clicking Stop aborts the measurement sequence as soon as the current modulation period is finished.

+ Point / Line

Starts the selection of the XY measurement position(s) in a topography Color map chart using the mouse cursor. These positions are automatically transferred to the appropriate entries in the Position section of the Spectroscopy panel. When selecting a line, clicking the chart once creates a line from the clicked position to the center of the image.

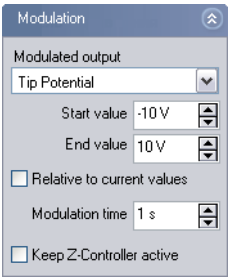
Photo

Captures the measurement currently displayed in the Spectroscopy window in a measurement document, and displays it in a separate window.
If Photo is clicked during the measurement, a copy is generated when the measurement in progress is finished. During the measurement, the button remains pressed. The capture process is cancelled by clicking Photo a second time.

The measurement documents are labelled automatically with increasing numbers (i.e. Image1, Image2,...). When leaving the program you will be asked if you want to save the unsaved measurement documents.

16.2: The Spectroscopy panel

Modulation (Easy, Standard, Advanced)



Modulated output (Easy, Standard, Advanced)
The number of available modulated outputs depends on the scan head and the number of installed modules . Possible values are: “Z-Axis”, “Tip Potential” and the names of the User Outputs.

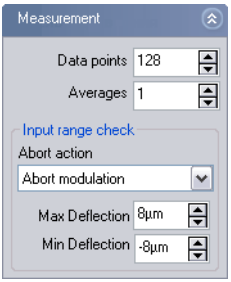
Start value/End value (Easy, Standard, Advanced)
The range over which the Modulated output is changed. The “Spec Forward” data is measured from the Start to the End value, the “Spec backward” data is measured in the opposite direction. The “Spec forward” data is always measured before the “Spec backward” data.

Relative to current value (Standard, Advanced)
When active, the Start and the End values are added to the value the modulated output had before starting the modulation.
When the Tip Potential is modulated, the current value is the Tip voltage set in the Z-Controller panel.
When the Z-Axis is modulated, the current value is the sample surface height, as measured using the Z-Controller output. Otherwise, the measurement Z-position is given by the value of the Ref. Z-Plane in the Imaging Panel.

Modulation time (Easy, Standard, Advanced)
The time used to change the Modulated output from the Start to the End value.

Keep Z-Controller active (Advanced)
The Z-Controller will continue to change the Z-position so as to keep the tip–sample interaction constant. This option is not available when the Modulated output is set to the Z-Axis.
This setting can for example be used to measure tip current as a function of applied voltage whilst keeping the tip–sample force constant.

Measurement (Easy, Standard, Advanced)



Data points (Easy, Standard, Advanced)
The number of data points in one spectroscopic measurement. The data points are equally distributed over the modulation range.

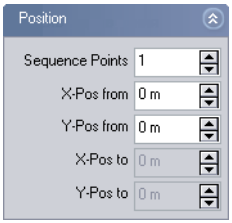
Averages (Easy, Standard, Advanced)
The number of times the modulation is repeated to obtain an averaged spectroscopic measurement. The measurement results of aborted modulations are discarded during averaging.

Input range check (Standard, Advanced)
In order to prevent tip damage due to too high tip–sample interaction, the settings below "Input range check" define a safe range of tip–sample interaction. When the interaction signal (Deflection in static modes, Amplitude in dynamic modes, Current in STM mode) leaves this safe range, the measurement is aborted. When a spectroscopy measurement has been aborted, a warning dialog is displayed. The number of aborts that occurred in a measurement is reported in Data Info panel as: ModAborted=<number of aborts>.

Abort action (Standard, Advanced)
Action to be performed when the measurement is aborted:
– **No range check** will never abort the measurement. The tip is not protected against damage due to too high tip–sample interaction. This is the default setting.
– **Abort modulation** aborts the current modulation period, and continues with the next modulation until the number of modulations in "Averages" is reached.
– **Abort current measurement** aborts the spectroscopy measurement for the current point and continues with the next point of the line, if a Line spectroscopy is being performed.
– **Abort measurement sequence** aborts the entire spectroscopy measurement sequence (cancels all "Averages" and points).

Max / Min input value (Standard, Advanced)
The Minimum/maximum value that the feedback signal is allowed to have.

Position (Easy, Standard, Advanced)



The Position parameters can be used to define a sequence of spectroscopy measurements on positions that are equally distributed over a line.

Sequence Points (Easy, Standard, Advanced)
The number of Spectroscopy Measurements to be made in the sequence.

X-Pos from/Y-Pos from (Easy, Standard, Advanced)
The XY-coordinates of the measured point in a + Point -spectroscopy measurement. Sets the XY-coordinates of the starting point of the line in a Line -spectroscopy measurement sequence.

X-Pos to Y-Pos to (Easy, Standard, Advanced)
The XY-coordinates of the end-point of the line in a Line -spectroscopy measurement sequence.

The from and to coordinates are more conveniently chosen using the + Point or Line tools in the Spectroscopy bar.

CHAPTER 17:

Lithography

CHAPTER 17: Lithography

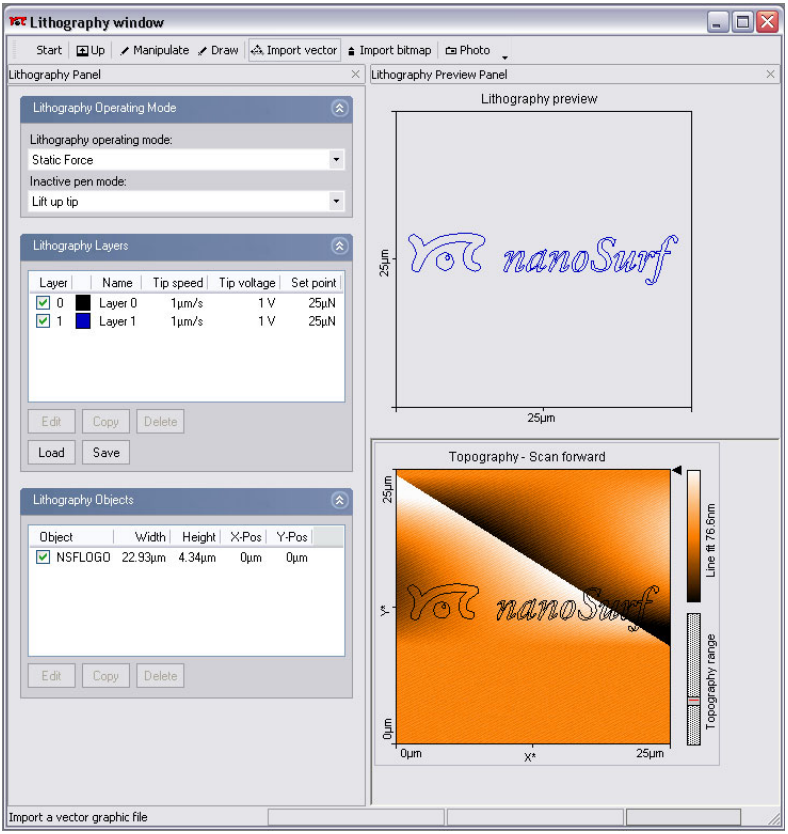


Figure 17-2: Lithography window

Lithography — in the context of Scanning Probe Microscopy (SPM) — is the process of modifying a sample surface with the goal of creating a pattern on that surface with the SPM tip. Depending on the operating mode and operating parameters used during the Lithography process, these modifications fall into two distinct categories:

1. Mechanical surface modification through "scratching" or "indenting" (Static Force mode), or through "hammering" (Dynamic Force mode). This type of modification require higher tip–sample interactions then normally

used during imaging, to mechanically transfer the desired pattern into the sample surface. The width an depth of the scratches or indentations made depend mainly on the force exerted on the SPM tip, and on its shape.

2. Electrochemical surface modification through voltage-dependent surface reactions. This type of modification requires a voltage difference between sample and tip, and will add molecules to the surface (e.g. through oxidation). The width and height of the oxidative surface modifications depend on the relative humidity of the ambient air, on the strength of the electric field, and on the tip speed.

17.1: Performing lithography

Lithography can be performed as of version 2.0 of the easyScan 2 control software, provided that suitable samples, tips, and lithography parameters are used. Lithography of objects drawn by hand and direct manipulation of the SPM tip is available for free via the Lithography window of the control software. Issuing of lithography commands through the Scripting Interface (which has been extended to include these commands) requires a license for the Scripting Interface. Import of vector or pixel graphics files to be used as patterns in the lithography process requires the licensed Lithography Option.

Lithography is performed in the Lithography window. This window can either be opened by clicking  in the navigator, or by clicking 

in the Imaging bar. When the Lithography window is activated from the Imaging bar, the currently measured image is transferred to the Spectroscopy window.

The Lithography window contains the Lithography bar, with commands that control lithography-related processes, and the Spectroscopy panel, with parameters that determine how the lithography is performed. By default, the Lithography window also contains the Lithography Preview panel (see *Section 17.4: The Lithography Preview panel* (page 182)) and a Color map of the current Topography measurement. The Lithography window can however display more charts, should this be desirable. For more information on adding and changing charts, see *Chapter 18: Viewing measurements* (page 185).

A typical lithography process is performed as follows:

1. The sample surface is imaged to identify an area that is suitable for transfer of a pattern. Suitable areas should preferentially be flat and dust-free.
2. The Lithography window is opened by clicking Litho in the Imaging bar of the Imaging window (see *Chapter 15: The Imaging bar* for details).
3. A pattern that was previously designed is imported.

   Suitable sources for patterns can either be (multi-layered) vector graphics files (GDS II, DXF, CIF, OAS, OASIS) or (multi-color/grayscale) pixel graphics files (BMP, DIB, GIF, TIFF, PNG, JPEG). A separate CAD program (LayoutEditor; *http://layout.sourceforge.net*) is included with the Nanosurf software to produce vector graphics files suitable for import. Pixel graphics files can be created or edited in any pixel-based image editor.

   After import of a vector or pixel graphics file, the pattern is referred to as a "Lithography object" in the Lithography window.

IMPORTANT

- In the case of vector-based objects, multiple lithography objects may be present (e.g. through sequential import) and used for lithography. In the case of pixel-based objects, only one pixel-based object can be present at any given time (other objects will be deleted upon import).
- As an alternative to designing the lithography pattern in a vector or pixel graphics file and then importing it into the lithography software, a freehand drawing mode is available in the Lithography window.

4. The imported object is positioned and scaled to fit the target area.
5. The Lithography sequence is executed.

IMPORTANT

As an alternative to step 3–5, a direct tip manipulation mode is available in the Lithography window.

6. The sample surface is re-imaged to view the Lithography results.

For more details on the lithography process (options and settings), please read all of the following sections.

17.2: The Lithography bar

Start / Stop

Start starts a lithography sequence and then changes to Stop until the lithography sequence is finished. Clicking Stop aborts the sequence.

Up / Stop

Up starts a single measurement and then changes to Stop until a full image has been scanned. Clicking Stop aborts the measurement. With Up the image is scanned from the bottom to top. If a measurement has been started using Up the measurement stops automatically after one full image.

IMPORTANT

When performing imaging from within the Lithography window, be sure to set valid imaging parameters in the Imaging and Z-Controller panels.

Manipulate

Starts the manual manipulation mode. It is now possible to control the movement of the tip by moving the mouse around the topography color map. When the left mouse button is held down, Lithography will be performed with the lithography operating mode set in Lithography panel, and with the parameters set in Layer 0 (the Tip speed setting is ignored). When the left mouse button is released, the tip will go to the inactive pen mode set in the Lithography panel, and will not move until the left mouse button is pressed again. Dragging the mouse slowly will produce smoother lines than dragging it fast.

Draw

Starts the manual drawing mode. A shape can now be drawn in the topography color map by clicking and holding the left mouse button. A shape can only consist of a single line. Repeating the above will erase the previous drawing. Double clicking the drawing will save it to the Lithography Object list.

Import vector

Opens an "Open File" dialog to import a GDS II vector graphic file (extension ".gds"). Other formats (DXF, OAS, OASIS, CIF) can be converted to GDS II using the LayoutEditor.

IMPORTANT

Since the Lithography software only supports a subset of the GDS II file format, an error message will appear when a file containing non-supported elements is selected. To avoid this error message, the vector graphics project should be fully flattened before saving it as a GDS II file. LayoutEditor and most other CAD programs provide some form of flattening functionality. Refer to the manual or (online) help of your CAD program for details.

For more information on the available import options after selecting a valid GDS II file, refer to *Section 17.2.1: The Vector Graphic Import dialog* (page 171).

Import bitmap

Opens a "Open File" dialog for importing a BMP, DIB, GIF, TIFF, PNG, or JPEG pixel graphics file.

IMPORTANT

Since the Lithography software only supports files with 256 pixels or less in width and height, an error message will appear when a non-supported file is selected. To avoid this error message, make sure to save all pixel graphics files with less than 256 pixels in width and height.

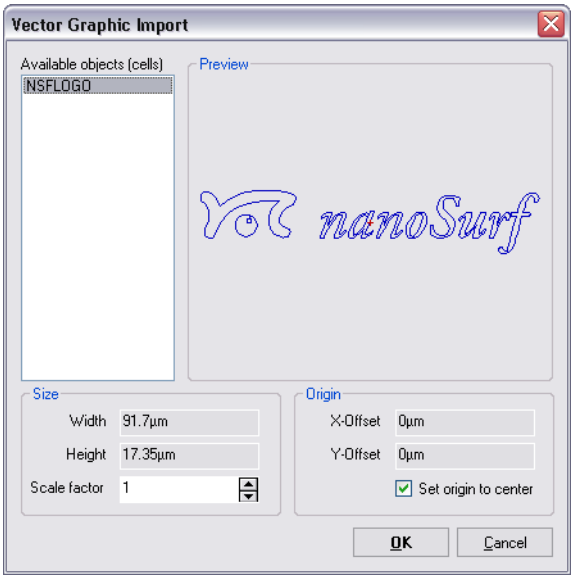
For more information on the available import options after selecting a valid pixel graphics file, refer to *Section 17.2.2: The Pixel Graphic Import dialog* (page 173).

Photo

Captures the measurement currently displayed in the "Lithography window" in a measurement document, and displays it in a separate window. If Photo is clicked during a measurement, a copy is generated as soon as the measurement in progress is finished. The capture process is cancelled by clicking Photo a second time. Measurement documents are automatically labeled with increasing

numbers (i.e. Image1, Image2, ...). When exiting the easyScan 2 software, you will be asked to save any unsaved measurement documents.

17.2.1: The Vector Graphic Import dialog



The Vector Graphic Import dialog appears after clicking the Import vector button and selecting a valid GDS II file, and can be used to select the object (cell) of the GDS II file to import. Size and origin of the resulting lithography object can be set during import using the Size and Origin fields (see description below), or after import using the Object Editor (see *Section 17.3.2: The Object Editor dialog* (page 181) for details).

Available objects (cells)
A list with all the valid objects (cells) of the selected GDS II file. Selecting an object will results in the respective object being displayed in the preview area of the Vector Graphic Import dialog, and will cause the selected object to be imported when the "OK" button is clicked. Objects can only be imported one at a time. Clicking the "Cancel" button will abort the import process.

Preview

Graphical area that displays the selected object in the available objects list (see above). The red cross (if visible) indicates the position of the object's origin.

Size

Width / Height
Displays width and height of the selected object (cell).

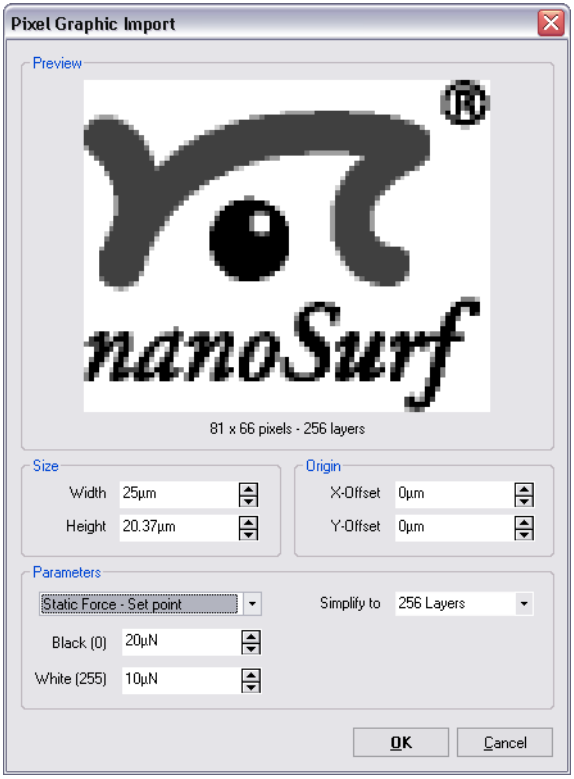
Scale factor
The factor by which the selected object (cell) will be scaled. A scale factor of 1 corresponds to the original object size. If the scale factor is changed manually, the object's width and height will be recalculated and displayed automatically.

Origin

X-Offset / Y-Offset
The X-Offset and the Y-Offset of the origin of the selected object (cell).

Set origin to center
When enabled, the origin of the object (cell) will be set to the center of the rectangle that encloses the object. When disabled, the origin will remain at the position that is defined in the object.

17.2.2: The Pixel Graphic Import dialog



The Pixel Graphic Import dialog appears after clicking Import bitmap and selecting a supported pixel graphics file, and can be used to specify how such a file is converted to a lithography object. All images are first converted to an 8-bit grayscale (256 levels). Each set of pixels with the same grayscale value will correspond to a separate layer in the resulting lithography object. Layers will only be generated for those grayscale values that are actually occupied. In addition, the number of layers can be reduced upon import (see *Simplify to* (page 176)).

For each layer, individual lithography parameters can be set. One of these lithography parameters can be automatically varied upon import, by using the

grayscale values of the imported pixel graphics file to define the selected parameter's range (see *Parameters* below). All parameters can of course always be modified manually after import (see *Section 17.3.1: The Layer Editor dialog* (page 178)).

Preview

Graphical area that displays the selected pixel graphics file.

Size

Width / Height
The width and the height of the lithography object resulting from the Pixel Graphic import. The default settings for width and height are taken from the dimensions of the current color topography map of the Lithography window. The pixel graphic is automatically resized to fit into the area defined by these dimensions while maintain its aspect ratio. It is at this point however possible to change the automatically calculated size manually. If the width is changed manually, the height is recalculated to keep the aspect ratio. If the height is changed manually, the width is not recalculated.

Origin

X-Offset / Y-Offset
By default the origin is in the center of the pixel graphic. By manually changing X-Offset and Y-Offset, the origin may be moved to a different position.

Parameters

This area allows selection of the lithography parameter that will be automatically varied, based on the different grayscale values of the imported pixel graphics file. The parameter values for the black and white pixels of the imported pixel graphic can be set, after which the parameter values corresponding to any in-between grayscale values are interpolated.

IMPORTANT

Since it is only possible to select one automatically adjusted lithography parameter per import, the other parameters must be set elsewhere. This is achieved by setting the Layer 0 parameters before import. The values entered here will be used as default values for all imported layers, except for the parameter that was explicitly selected in the Pixel Graphics Import dialog.

All values and settings in the parameters section are stored when the dialog is closed. They will be automatically used the next time the dialog is opened.

From the drop-down list box, one of the following parameters may be selected for automatic calculation:

- Tip speed
- Tip voltage
- STM Set point
- Static Force Set point
- Dynamic Force Set point
- Dynamic Force Amplitude

Black / White
Used to enter the parameter values for black and white pixel values, which form the basis for the interpolation of the in-between color/grayscale pixel values.

Example

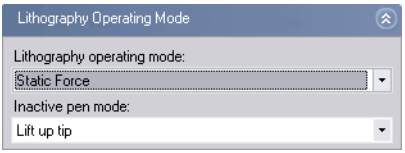
Setting the automatically adjusted Lithography parameter to “Static Force Set point”, and Black (layer 0) and White (layer 3) to 25 µN and 10 µN, respectively, will result in:

- Layer 0 (black pixel layer) having a Static Force Set point of 25 µN
- Layer 1 (gray pixel layer 1) having a Static Force Set point of 20 µN
- Layer 2 (gray pixel layer 2) having a Static Force Set point of 15 µN
- Layer 3 (white pixel layer) having a Static Force Set point of 10 µN

Simplify to
Select the number of layers the imported pixel graphics file should be simplified to. Selecting the number of layers to be identical to the number of grayscale values in the pixel graphics file will results in no simplification taking place. In all other cases, simplifications are performed through binning of layers.

17.3: The Lithography panel

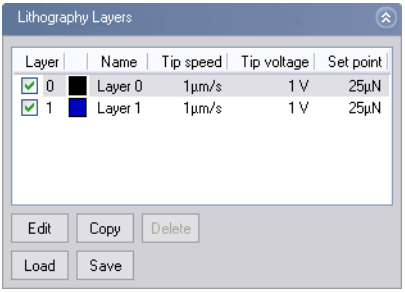
Lithography Operating Mode (Easy, Standard, Advanced)



Lithography operating mode (Easy, Standard, Advanced)
Used to select the operating mode during lithography operation:. The following options are available:
– **Static Force**
– **Dynamic Force**
– **STM (STM only)**

Inactive pen mode (Easy, Standard, Advanced)
Action to be performed when the tip is moving from one end point to a new start point, in case the end point and start point are not the same. The following options are available:
– **Lift up tip** Only lift the tip (upper position of the Z-actuator of the scan head). No feedback will be performed by the Z-Controller during travel to the new start point.
– **Standard operating mode** Switch the Z-Controller operating mode back to the one selected in the "Operating Mode Panel" during imaging. All values such as Tip speed, Tip voltage, Set point etc. will temporarily chance back to the values used for imaging. The Z-Controller will be active during travel to the new start point.

Lithography Layers (Easy, Standard, Advanced)



Layer list (Easy, Standard, Advanced)
Lists all layers that are present in the objects shown in the Lithography Objects list. Layer 0 is always present, even if no lithography objects exists, and may be used to set the default Lithography parameter values (see *Parameters* (page 174) in *Section 17.2.2: The Pixel Graphic Import dialog* for details).

Edit (Easy, Standard, Advanced)
Edit will open the "Layer Editor" dialog to edit the selected layer.

Copy (Easy, Standard, Advanced)
Copy will open the "Layer Editor" dialog (see *Section 17.3.1: The Layer Editor dialog*) to edit the selected layer before copying it. When changes have been made (if any) and the "OK" button is clicked, a new layer is generated.

IMPORTANT

Upon creation of a new layer, the layer number will be incremented to the next available layer number. If a total of 256 layers is reached, no more layers can be added.

Delete (Easy, Standard, Advanced)
Used to delete a layer. Delete will open a warning dialog to confirm the deletion of the selected layer.

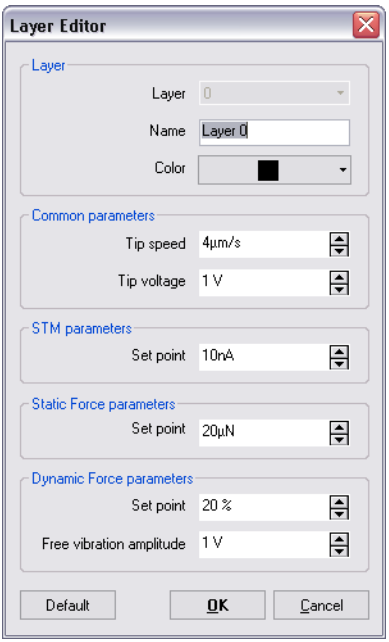
IMPORTANT

Only layers currently not assigned to any object can be deleted.

Load (Easy, Standard, Advanced)
Load a predefined layer list ".lld". Layers that are needed to display the current objects that are not part of the loaded list will be created.

Save (Easy, Standard, Advanced)
Save all the layers to a layer list file ".lld".

17.3.1: The Layer Editor dialog



The Layer Editor is used to set the controller parameter values to be used during lithography.

Common parameters

Used to set the common parameters Tip speed and Tip voltage. Tip speed determines the drawing speed during lithography, Tip voltage determines the voltage set to the tip during oxidative Lithography.

STM parameters

Used to set the tunneling current Set point of the Z-Controller during STM Lithography.

Static Force parameters

Used to set the set point of a lithography sequence performed in Static Mode.

Dynamic Force parameters

Used to set the Set point and Free vibration amplitude of a lithography sequence performed in Dynamic Mode.

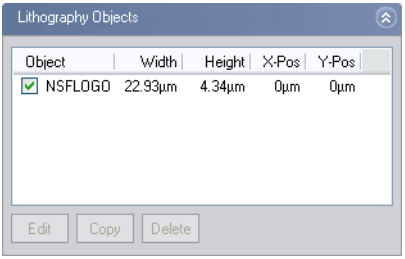
Default

The button "Default" may be pressed to recall the default lithography parameter values, listed in *Table 17-1: Default lithography parameter values* below.

Section	Parameter	Default Value
Common parameters	Tip speed	4 µm/s
	Tip voltage	1 V
STM parameters	Set point	10 nA
Static Force parameters	Set point	20 µN
Dynamic Force parameters	Set point	20%
	Free vibration amplitude	1 V

Table 17-1: Default lithography parameter values

Lithography Objects (Easy, Standard, Advanced)



Object list (Easy, Standard, Advanced)
List of all available objects. Objects may be selected or deselected by checking or unchecking the checkbox. If the object is unchecked it will not be used for a lithography session.

Edit (Easy, Standard, Advanced)
Edit will open the "Object Editor" dialog to edit the selected object.

Copy (Easy, Standard, Advanced)
Copy will open the "Object Editor" dialog to edit the selected object before copying it.

Delete (Easy, Standard, Advanced)
Delete will delete the selected object. A warning dialog will appear for confirmation of this action.

17.3.2: The Object Editor dialog



Preview

The red cross (if visible) indicates the origin position of the object.

Object

Name
The name that is used to describe the object. Default names are generated during import, based on the GDS II object names, or on the pixel graphic filename, but may be edited here afterwards.

Width/Height
Displays the width and the height of the object.

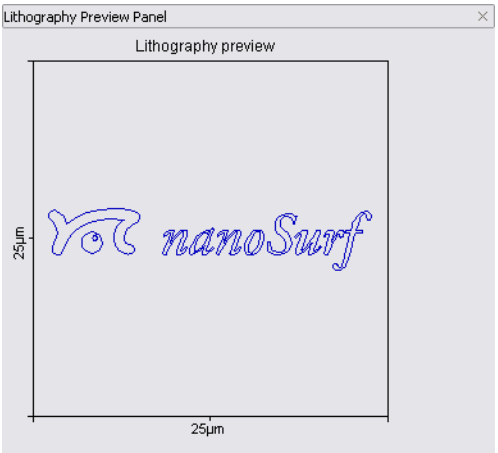
Scale factor
The factor by which the object can be scaled. If the scale factor changes the width and the height will be automatically recalculated. Scale factor 1 represents the original state.

Position

X-Pos/Y-Pos
The X-Pos and the Y-Pos may be used to move the object within the space of the topography map.

Move to Center
Moves the origin on the selected object back to the center of the topography map.

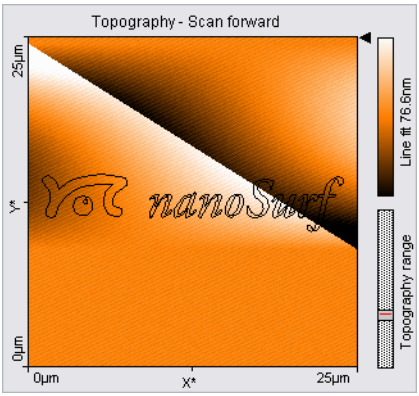
17.4: The Lithography Preview panel



Lithography preview

The preview panel displays all currently selected objects and layers (of the objects and layers list) as they would be executed on the sample surface.

17.5: The Lithography Topography map view



Lithography Topography map view

The Lithography Topography map view displays the topography image of the sample surface to be used for lithography.

Before running a lithography sequence, a box with the size of the selected lithography object is superimposed on top of the surface map. When selecting the center of the box with a mouse, the corresponding object can be moved around the scan area to reposition it. The new object location (X-Pos and Y-Pos) is however only transferred to the object's properties (as displayed in the Lithography Objects list, and graphically shown in the Lithography Preview area) when double-clicking the box after repositioning. Otherwise, any changes made are not implemented.

While a lithography sequence is running, the box disappears and the progress of the drawing process will be displayed live using superimposed black lines (see image above). After a lithography sequence has been completed, the black lines will remain visible until a new lithography sequence is started.

CHAPTER 18:

Viewing measurements

CHAPTER 18: Viewing measurements

Charts and the Data Info panel together display all measurement information.

Charts display the measured data. Charts occur in Measurement document windows, the Imaging window and the Spectroscopy window.

The Data Info panel displays information about the measurement, most importantly measurement settings.

18.1: Charts

A Chart consists of a graphical representation of the measured data and additional elements that give information about the chart itself (*Figure 18-1: Elements of a Chart*).

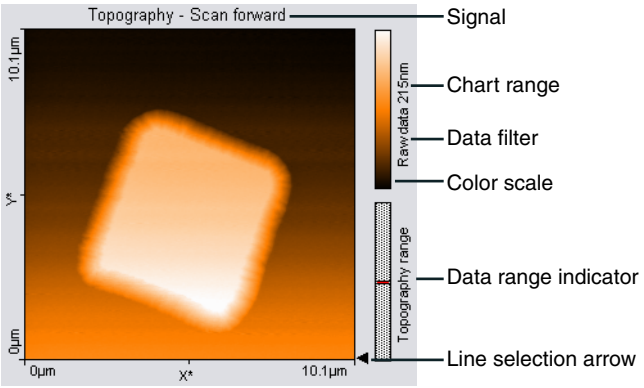


Figure 18-1: Elements of a Chart

These additional elements show the displayed Signal, Chart type, the type of Filtering applied to the data, and the Color scale used to display the data. The Color scale shows which measured signal level is mapped to which color. The color mapping can be changed using the Color Palette dialog, described further on in this section. The Data range indicator shows the range of possible measurement values that is occupied by the measured data.

The Chart bar is used to create new charts and to modify their properties. The chart configuration of the Imaging and Spectroscopy window can be saved to a

file. The chart configuration of the measurement documents is saved together with the document.

18.1.1: Storing and retrieving the chart arrangement

The chart arrangement of the Imaging and Spectroscopy windows is stored in a configuration file with the extension ".chart". When the easyScan 2 software is started, a default arrangement is loaded from a file that is selected in the Controller Configuration dialog (*Section 13.5: The Controller Configuration dialog* (page 136)). Functions for storing and retrieving the chart arrangement are accessed via the menu "File" >> "Chart Arrangement".

"Save" saves the chart arrangement to the currently selected chart file. The name of this file is indicated in the status bar at the bottom of the main window.

"Save as...", saves the chart arrangement under a new file name.

"Load" loads a previously saved chart file.

IMPORTANT

When you have not loaded another file, "Save" will overwrite the original default chart arrangement file with the current settings.

18.2: The Chart bar

The properties of the charts are set using the Chart bar. The settings displayed in the Chart bar refer to the currently active chart. This chart is indicated by a gray line around the chart. A Chart is activated by clicking it with the mouse cursor.

The following buttons control the creation and modification of the charts.


Create new Chart
Creates a copy of the currently active chart and adds it as the last chart in the active window. Charts are first ordered top to bottom, then left to right. The window may have to be resized to see all charts.


Delete Current Chart
Removes the currently active chart.

Chart type

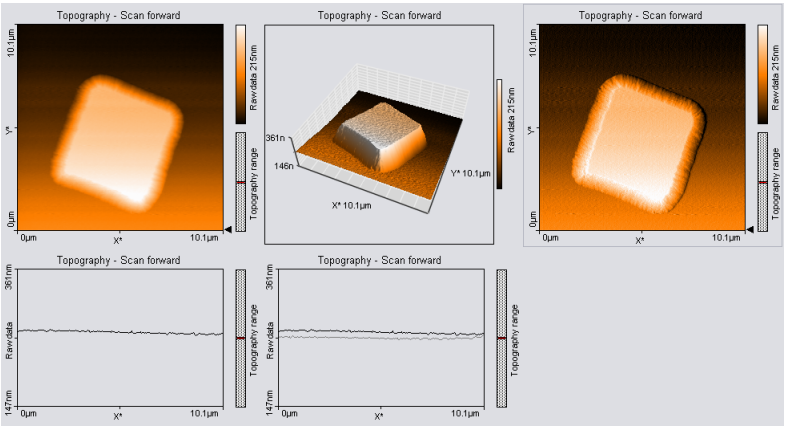


Figure 18-2: Chart types:. Data represented using different chart types

The following chart types are available:

– **Line graph** data is displayed as a plot. Points outside the range of the scanner are displayed in red. The displayed line is selected by dragging the Line selection arrow in a Color map or Shaded map chart (*Figure 18-1: Elements of a Chart* (page 186)).

– **Color map** data is encoded in a color scale

– **3D view** data is shown as a 3-dimensional representation in a parallel perspective, see *Section 18.2.2: Changing the appearance of the 3D view* (page 191)

– **Shaded map** creates an impression of the surface with lighting from the left. This is achieved by combining the topography with its derivative.

– **Dual line graph** both the Forward and the Backward data (when available) are displayed as in the "Line graph". The line of the data type selected in "Signal" is black, the line of the reverse direction data is gray.

Data filter

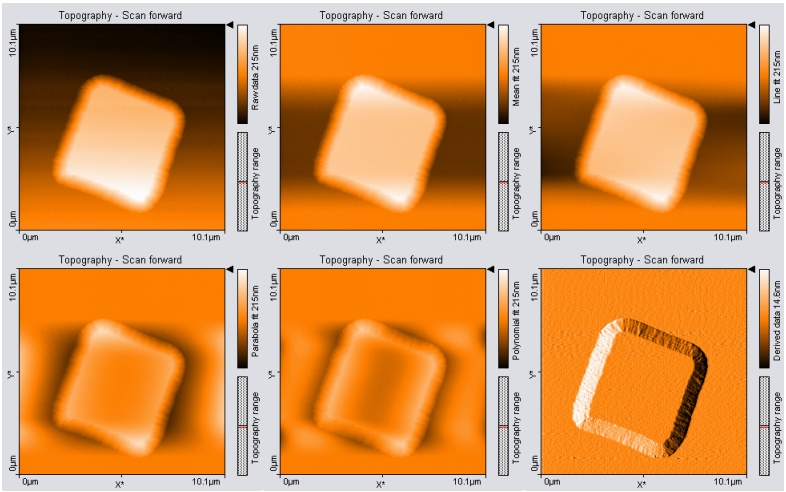


Figure 18-3: Data filter types. The same measurement data displayed with different filters.

The easyScan 2 software can process/filter measured data before displaying it, without modifying the original measurement data. The available data filters are:

– **Raw data** no data processing.

– **Mean fit** calculates the mean value of each line of data points and subtracts the mean value from the raw measurement data of that line.

– **Line fit** calculates the best fit line (mean value and slope) for each line of data points and subtracts the best fit from the raw measurement data of that line.

– **Derived data** calculates the difference between two successive data points (derivative).

– **Parabola fit** calculates the best fit parabola for each line of data points is calculated and subtracts the best fit from the raw measurement data of that line.

– **Polynomial fit** calculates the best fit fourth order polynomial for each line of data points is calculated and subtracts the best fit from the raw measurement data of that line.

Signal
The input channel that is displayed. The available signals depend on the operating mode, the status of the User input (*Section 13.1: The Operating Mode panel* (page 114)) and the operating mode (*Section 15.2: The Imaging panel* (page 151)).

Optimize Chart range
Adjust the chart scale so that it optimally fits the displayed data.

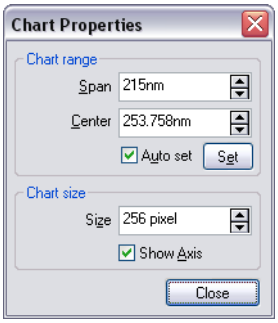
Decrease Chart range
Halves the chart scale, thereby increasing feature contrast / height.

Increase Chart range
Doubles the chart scale, thereby decreasing feature contrast / height.

Chart properties dialog
Opens the chart properties dialog.

18.2.1: The Chart Properties dialog

Chart range



Span
The signal span that corresponds to the full chart scale. Increasing Span decreases the feature contrast. The current Span is also displayed next to the color bar / axis in the chart

Center
The signal that corresponds to the center of the chart scale.

Auto set
When active, the chart scale is automatically set to optimally fit the displayed data, as it is being acquired. Clicking Set has the same effect as clicking the "Optimize Chart range" button.

Chart size

Size
The size of the chart in pixels.

Show Axis
When active, the labels in charts and the color-bar in "Color map" window, are displayed.

18.2.2: Changing the appearance of the 3D view

Always click and hold the left mouse button on the 3D view chart while changing the 3D view. The surface is reduced in feature complexity as long as the left mouse button is pressed. Press the following additional keys/buttons to determine what chart property is changed:
– **Surface rotation** mouse left/right
– **Surface tilt** mouse up/down.
– **Size displayed surface** "Ctrl"- key + mouse up/down
– **Surface position** "Shift"-key + mouse up/down/left/right
– **Z-scale magnification** left mouse button + right mouse button + mouse up/down
– **Light source direction (360°)** "Shift"+"Ctrl"-key + mouse left/right
– **Light source height (0°–90°)** "Shift"+"Ctrl"-key + mouse up/down

The lowest height of 0° corresponds to "sunset" lighting, the highest height corresponds to mid-day lighting at the equator.

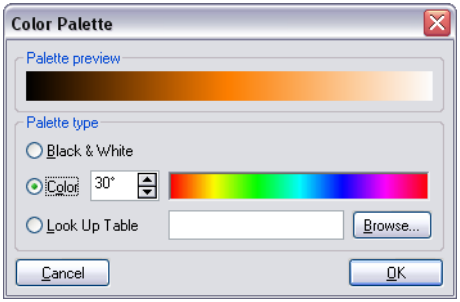
The Chart Properties "Span" and "Center" can be used to cut off high and or low features of the surface.

Tip

To create good-looking 3D images you can use any of the following features:

- Use the Tools "Correct Scan Line Level", "Glitch" and "Noise reduction" filters to remove unwanted measurement artefacts.
- Set the light source direction to 90° (parallel to the scan lines).
- Click once or twice until no clipping of high features is visible (or adjust the "Span" and "Center" Properties).

18.2.3: The Color Palette dialog



The color palette dialog is reached via the menu item "Options" >> "Config Color palette...". The color palette is used to map the display range of the measured values to a color. Three different palette types are available:

– **Black&White** The color map is a linear gray scale

– **Color** The color selection uses the HSB-color model where the color (H) is set in ° value. The color is selected by entering a number or by clicking a color in the color bar.

– **Look Up Table** A user definable palette (with max 256 color entries) can be selected. This palette is stored in a ".lut" file that contains an ASCII table with RGB color values. A different look up table can be selected by clicking the "Browse..." button.

18.3: The Data Info panel

The Data Info panel can be opened by clicking  in the navigator, and displays detailed information about the measurement, such as the current tool results, the measurement date and time, the measurement parameters, and the hardware that was used.

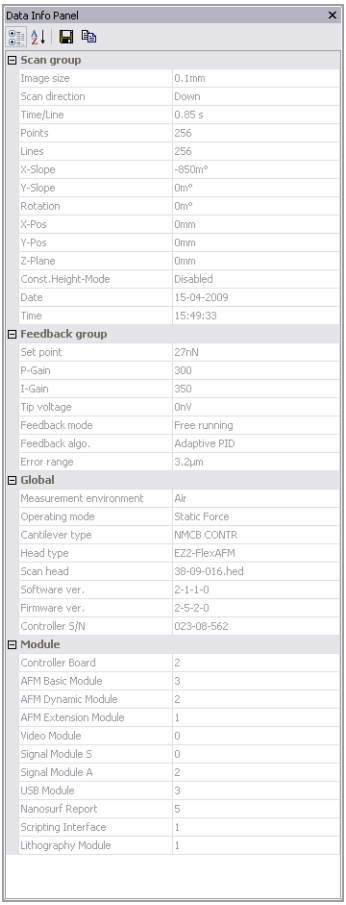


Figure 18-4: The Data Info panel. Display of measurement parameters.

CHAPTER 19:

Quick evaluation tools

CHAPTER 19: Quick evaluation tools

The easyScan 2 software has several tools that allow quick numerical evaluation of a measurement while it is being acquired, or when the acquisition is finished. This helps find optimal measurement settings. For more elaborate evaluations, the optional Nanosurf Analysis or the Nanosurf Report software package can be used (*Section 20.2: Creating a report* (page 214)).

To use a quick evaluation tool:

1. Click the chart to evaluate to activate it.
   Tools can be used in all chart types, with the exception of the 3D View. The number of available tools depends on the type of the chart.
2. Click on one of the buttons on the Tools bar or select a tool from the Tools menu.
   The Tool Results Panel now becomes visible. This panel displays the evaluation results.
3. Define the evaluation.

The procedure to define the evaluation differs between the tools; refer to *Section 19.2: The Tools bar* (page 199) for tool-specific instructions.

To stop using a tool:

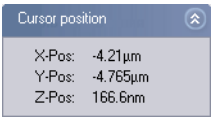
- Select another tool, or select the same tool a second time.

19.1: The Tool Results panel

The Tool Results panel displays the evaluation results of the currently active tool. The panel becomes visible when a tool is selected. When the panel is not visible, click  in the navigator. The contents of the tool results panel depend on the tool that is active. The panel always contains a Cursor position and usually a Tool status section. The Tool Results panel may also contain a Tool result and a Tool chart section.

The Cursor position section

Displays the coordinates of the mouse cursor when the cursor is inside the currently active chart.



X,Y-Pos
The X- and Y-measurement position.

Z-Pos
The displayed value depends on the chart type:

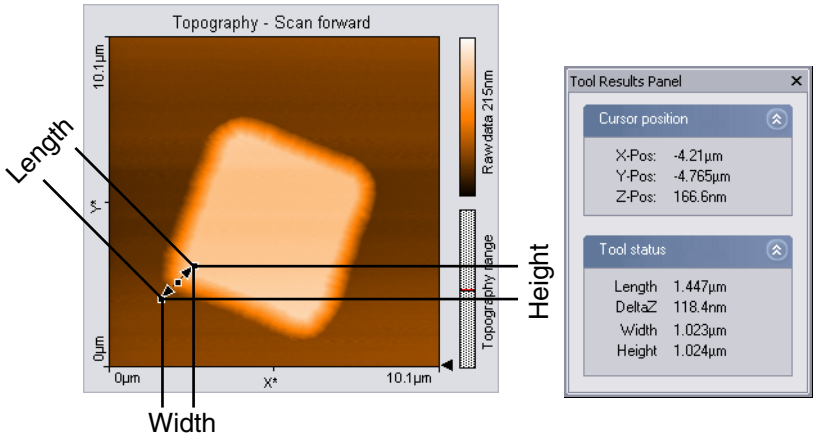
– **Color map and Shaded map charts** Z-Pos is the data value at the cursor position.When evaluating these charts, the displayed Z-Pos value depends on the data filter of the chart, because the Z-Pos is taken from the filtered data. More information on data filters is provided in *Section 18.2: The Chart bar* under *Data filter* (page 189).

– **(Dual) line graph charts** Z-Pos is the cursor position. When evaluating these charts, the displayed value only depends on the cursor position. The value is independent of the data, so the Data filter has no effect.

The Tool status section

Displays the evaluation result of the currently active tool.

The tools that require drawing an arrow to define the evaluation have some common parameters that are described here. The other parameters are described in the section that describes the tool.



Length
The length of the arrow in the plane of the chart. It is related to the evaluation results Width and Length according to the formula:

$$Length = \sqrt{Width^2 + Height^2}$$

Example: In a Color map chart, length is calculated in the XY-Plane. In a Line graph chart, length is calculated in the XZ-Plane.

Width, Height
The width and height of the arrow in the chart, calculated in the plane of the chart.

DeltaZ
The difference between the Z-Pos values at the start and the end of the arrow.

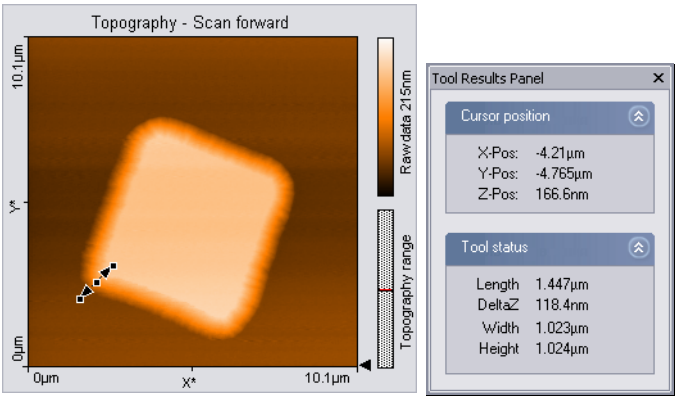
IMPORTANT

- In a Color map chart, DeltaZ is the difference in the (filtered) sample height between the start and the end point.
- The calculated values of Length, Width and Height only depend on the cursor positions, they do not on depend the displayed data values.

19.2: The Tools bar

The Tools bar is for activating one of the following tools:

Measure Length
Calculates the distance and signal difference between two points.



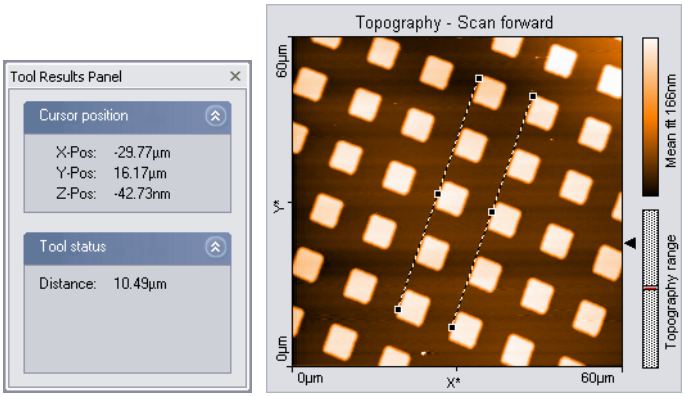
The two points are defined by drawing a double arrow. The first point is defined by the mouse cursor position where the left mouse button is clicked, the second point by the position where the button is released. When the mouse is not moved between clicking and releasing, an arrow parallel to the X*-axis is drawn.

The direction of the arrow can be adjusted by dragging its end markers; it can be moved by dragging the center marker.

The Tool status section of the Tool Results panel displays the calculated Length, DeltaZ, Width and Height. The Data Info Panel of the measurement document stores these results as long as the tool is active. For more information on the data in the Tool status section, see *The Tool status section* (page 197).

Measure Distance

Calculates the distance between two parallel lines.

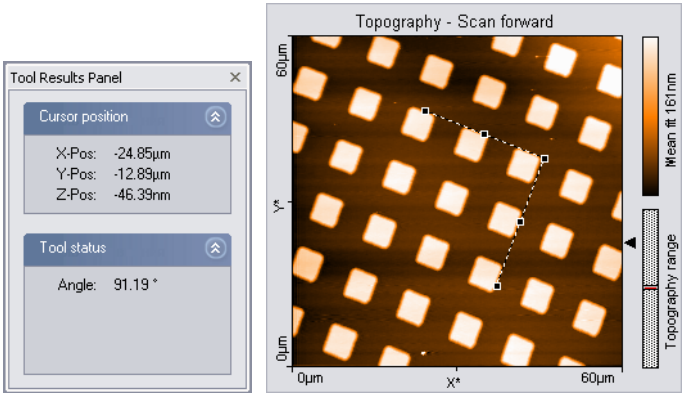


The parallel lines are defined by drawing them in the chart. The first point of the first line is defined by the mouse cursor position where the left mouse button is clicked, the second point by the position where the button is released. When the mouse is not moved between clicking and releasing, a line parallel to the X*-axis is drawn. After releasing the mouse button, a second parallel line sticks to the mouse cursor, that is released by clicking its desired position. The direction of the parallel lines can be adjusted by dragging their end markers; they can be moved by dragging the center marker.

The Tool status section of the Tool Results panel displays the calculated distance. The distance value only depends on the cursor positions, it does not on depend the displayed data values. The Data Info Panel of the measurement document stores the distance as long as the tool is active. For more information on the Tool status section, see *The Tool status section* (page 197).

Measure Angle

Calculates the angle between two lines. In Line graph-type displays, this tool can only be used when the chart displays data that has the unit “meters”.

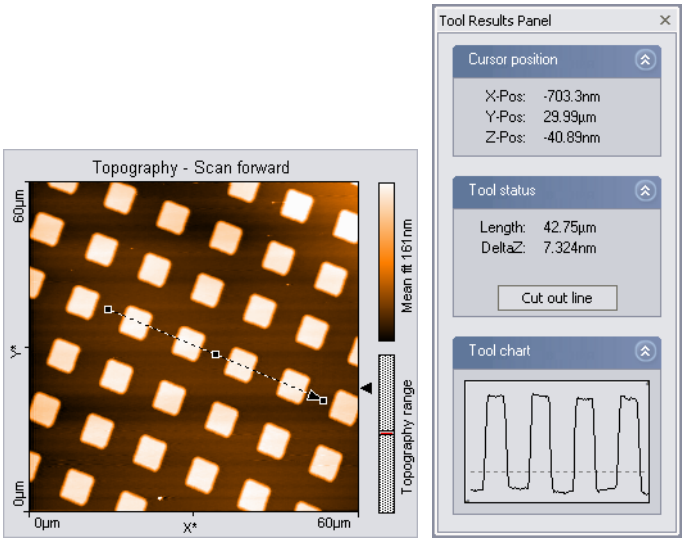


The two lines are defined by drawing them in the chart. The first point of the first line is defined by the mouse cursor position where the left mouse button is clicked, the second point by the position where the button is released. When the mouse is not moved between clicking and releasing, a line parallel to the X*-axis is drawn. After releasing the mouse button, the end of the second line sticks to the mouse pointer. The end is released by clicking its desired position. The angle can be changed by dragging the line end point markers or the corner mark; it can be moved by dragging the line center markers.

The Tool status section of the Tool Results panel displays the calculated angle. The angle value only depends on the cursor positions, it does not on depend the displayed data values. The Data Info Panel of the measurement document stores the angle as long as the tool is active. For more information on the Tool status section, see *The Tool status section* (page 197).

Create Cross Section

Creates a new measurement document containing a line cross-section of a Color map or Line View display.



The line is defined by drawing an arrow. The arrow points toward the forward direction of the line. The start of the arrow is defined by the mouse cursor position where the left mouse button is clicked, the end of the arrow by the position where the button is released. When the mouse is not moved between clicking and releasing, an arrow ending in the center of the measurement is drawn. The direction of the arrow can be adjusted by dragging its end markers; it can be moved by dragging the center marker.

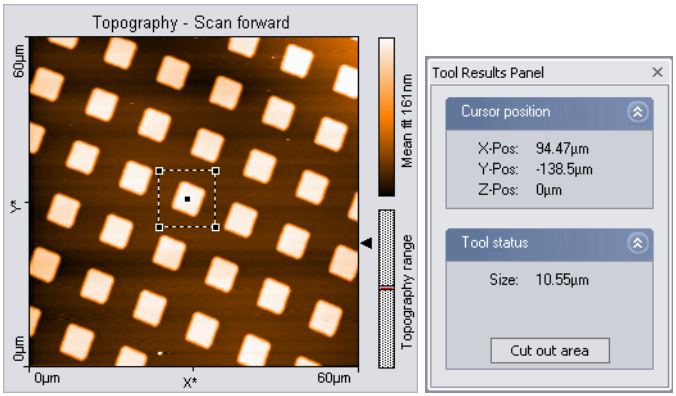
Double clicking the graph, or clicking the “Cut out line” button in the Tool Results panel creates a new measurement document that contains the line section.

The Tool chart section of the Tool Results panel displays preview chart of the selected line.

The Tool status section of the Tool Results panel displays the calculated Length and DeltaZ of the selected line. For more information on the Tool status section, see *The Tool status section* (page 197).

Cut Out Area

Creates a new measurement document containing a subsection of an existing measurement.



One corner of the area is defined by the mouse cursor position where the left mouse button is clicked, the opposite corner by the position where the button is released. When the mouse is not moved between clicking and releasing, an area is defined that has a size of 33% of the current measurement, and is centered on the clicked location. Once an area is defined, it can be resized by dragging one of its corners, and moved to the desired position by dragging its center point.

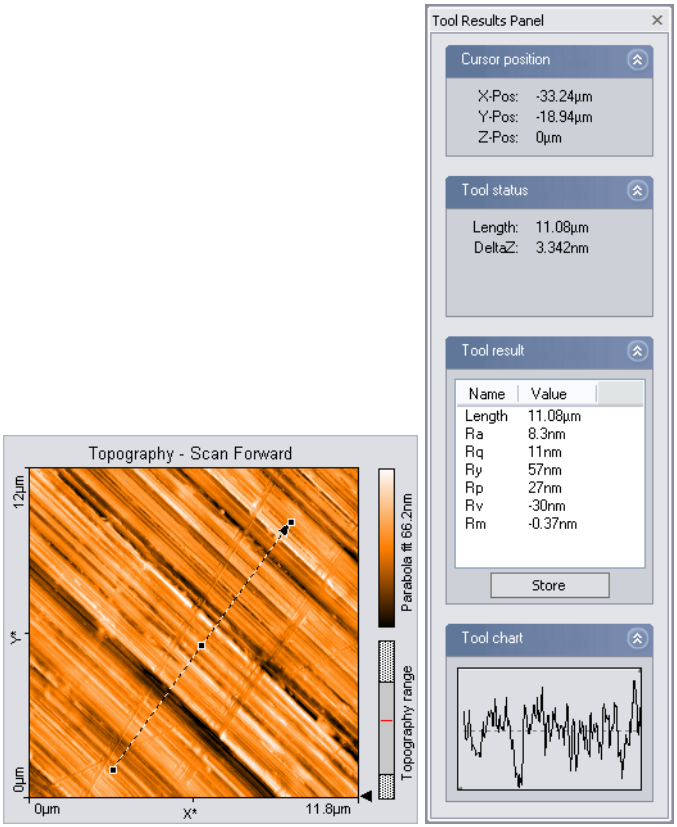
Pressing “Shift” key whilst dragging a corner defines a rectangular (i.e. non-square) area.

Double clicking the graph, or clicking the “Cut out area” button in the Tool Results panel creates a new measurement document that contains the selected area.

The Tool status section of the Tool Results panel displays the calculated Size or Width and Height of the selected area. For more information on the Tool status section, see *The Tool status section* (page 197).

Calculate Line Roughness

Calculates several roughness parameters from the data at points along a selected line.



The line is selected in the same way as with the Cut out Line tool.

The Tool status section of the Tool Results panel displays the calculated Length and DeltaZ of the selected area. For more information on the Tool status section, see *The Tool status section* (page 197).

The Tool result section displays the roughness values that are calculated from the data according to the following formulas:

The Roughness Average, S_a

$$S_a = \frac{1}{N}\sum_{l=0}^{N-1} | z(x_l) |$$

The Mean Value, S_m

$$S_m = \frac{1}{N}\sum_{l=0}^{N-1} z(x_l)$$

The Root Mean Square, S_q

$$S_q = \sqrt{\frac{1}{N}\sum_{l=0}^{N-1} (z(x_l))^2}$$

The Valley depth, S_v

S_v = *lowest value*

The Peak Height, S_p

S_p = *highest value*

The Peak-Valley Height, S_y

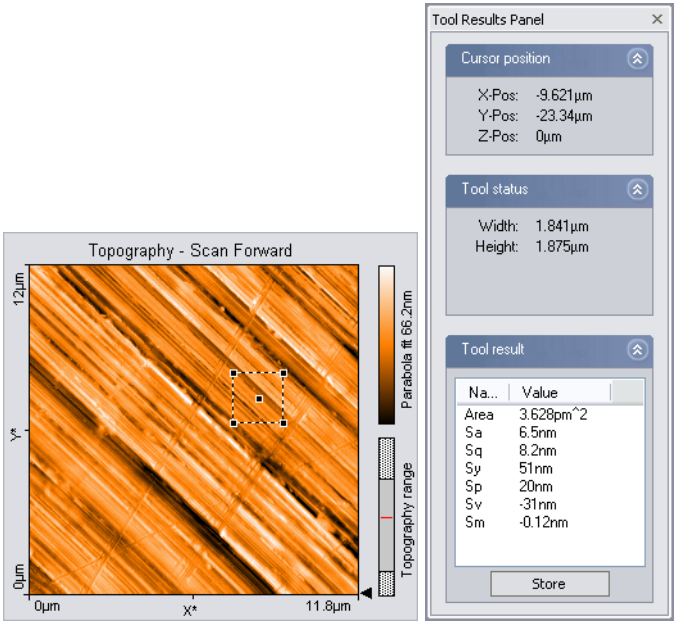
$S_y = S_p - S_v$

The roughness values depend on the Data filter that is applied to the chart, because they values are calculated from the filtered data. More information on data filters is provided in *Section 18.2: The Chart bar* under *Data filter* (page 189).

Clicking the "Store" button in the Tool result section stores the roughness values in the Data Info Panel of the measurement document.

Calculate Area Roughness

Calculates several roughness parameters from the data points in a selected area.



The area is selected in the same way as with the Cut out Area tool.

The Tool status section of the Tool Results panel displays the calculated Size or Width and Height of the selected area. For more information on the Tool status section, see *The Tool status section* (page 197).

The Tool result section displays the roughness values that are calculated from the data according to the following formulas:

The Roughness Average, S_a

$$S_a = \frac{1}{MN} \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} | z(x_k, y_l) |$$

The Mean Value, S_m

$$S_m = \frac{1}{MN} \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} z(x_k, y_l)$$

The Root Mean Square, S_q

$$S_q = \sqrt{\frac{1}{MN} \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} (z(x_k, y_l))^2}$$

The Valley depth, S_v

S_v = *lowest value*

The Peak Height, S_p

S_p = *highest value*

The Peak-Valley Height, S_y

$S_y = S_p - S_v$

The roughness values depend on the Data filter that is applied to the chart, because they values are calculated from the filtered data. More information on data filters is provided in *Section 18.2: The Chart bar* under *Data filter* (page 189).

Clicking the "Store" button in the Tool result section stores the roughness values in the Data Info Panel of the measurement document.

Tip

The Area Roughness tool can be used to determine the mean height difference between two plateaus with more accuracy than with the "Measure Distance" tool. To determine the mean height difference, select an area on each plateau, and calculate the difference between their Sm-values.

Correct Background

Removes the effect of a wrong scan plane when the "average" and "plane" Data filter options do not give satisfactory results. This may occur when the scan lines in different parts of the measurement have a different average height. An example of such a measurement is shown in *Figure 19-1: Correct Background*.

To use the tool, select three points that should be on the same height. This is done in the same way as with the angle tool. The selected points are the end points of the two connected lines.

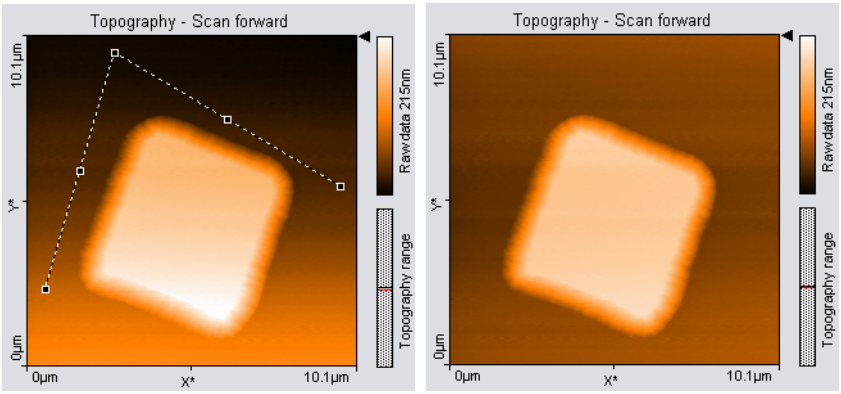


Figure 19-1: Correct Background. (left) uncorrected image, the end points of the lines have been moved to points that should have the same height, (right) corrected image

After clicking the "Execute" button in the Tool Results Panel, the plane that is defined by the three points is subtracted from the measurement. To get useful results, the Data filter option for the display in which you draw the line should generally be "Raw data".

Correct scan line levels

Removes the effect of drift when the "average" and "plane" Data filter options do not give satisfactory results. This may occur when the scan lines in different parts of the measurement have a different average height. An example of such a measurement is shown in *Figure 19-2: Correct scan line levels*.

To use the tool, draw a line through points that should have the same height in the same way as with the Measure Length tool.

After clicking the "Execute" button in the Tool Results Panel, the average level of each scan line is adjusted so that all points along the drawn line have the same height. To get useful results, the Data filter option for the display in which you draw the line should generally be "Raw data" or "Mean fit".

Glitch Filter

The Glitch Filter removes the effect of small defects in the image such as single short glitches in the scan. Compared to the Noise Filter, it has the advantage of

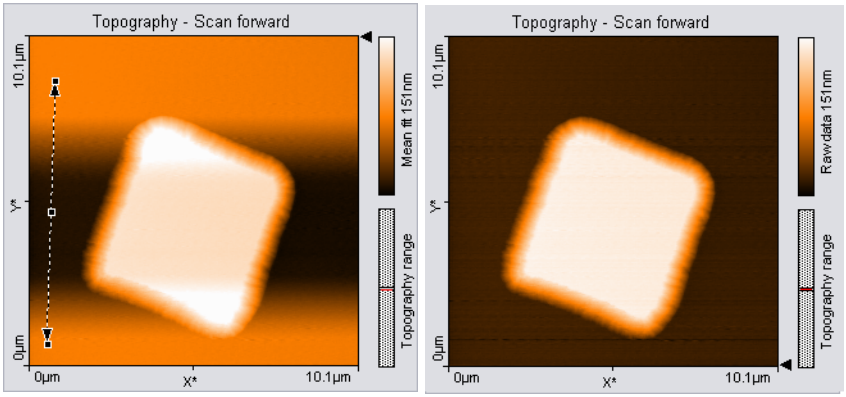


Figure 19-2: Correct scan line levels. (left) uncorrected image with a line through points that should be at the same height, (right) corrected image

not reducing resolution on step edges. The glitch filter is implemented as a Median filter on a 3×3 pixel matrix.

To apply the filter, activate the color map chart that is to be filtered, then click the "Glitch Filter" button in the Tools bar. A new Measurement document with the filtered data is created.

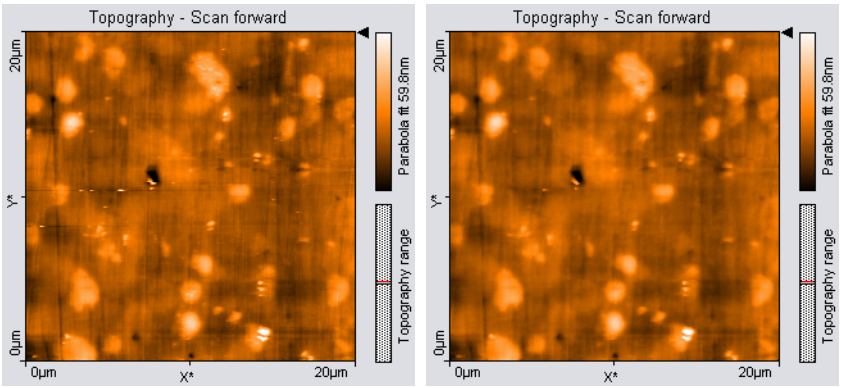


Figure 19-3: Glitch Filter. (left) unfiltered image with some glitches where the tip lost contact with the sample, (right) corrected image

Noise Filter

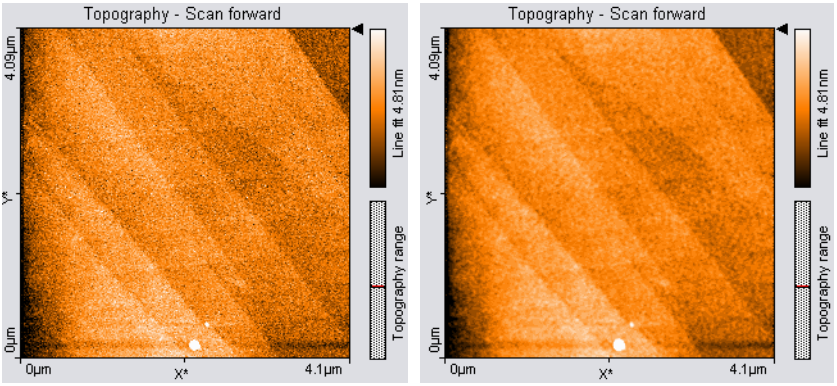


Figure 19-4: Noise Filter. (left) unfiltered image of AFM measurement on HOPG, (right) filtered image

The Noise filter removes high frequency noise from the image, but applying the filter will also decrease the resolution of the image. The Noise Filter is implemented as a convolution with a 3×3 pixel Gaussian kernel function.

To apply the filter, activate the color map chart that is to be filtered, then click the "Noise Filter" button in the Tools bar. A new measurement document with the filtered data is created.

Tip

- Filters are especially useful for improving the appearance of 3D views.
- Applying filters may changes the result of the other tools. This may result in incorrect results when evaluating sample roughness.

CHAPTER 20:

Storing and processing data

CHAPTER 20: Storing and processing data

20.1: Storing and printing measurements

Storing and Printing of measurement documents can be performed using the File menu. The functions Open, Save and Print are also available via the File bar.

Menu item “File” contains the items for opening, closing, saving, and printing the measurement documents and for exiting the program. In the following only the special functions are mentioned.

Open

Opens a dialog for opening Nanosurf “.nid” or “.ezd” (easyScan 1) files. The same dialog is opened using the menu “File” >> “Open...”. It is possible to select more than one file at the same time by using the “Shift” and “Ctrl” keys.

“Save” and “Save as...”

Save a measurement document in Nanosurf image data format (file extension “.nid”). The same dialog is opened using the menu “File” >> “Save” and “File” >> “Save as...”.

Export Current Chart as / Current document as

Exports either the active chart or the whole active measurement document for use in other programs or image processing software. Available data types for documents are tagged image file format (.tif), portable network graphics (.png), Windows bitmap (.bmp), 16 bit data file (.dat), and plot file (.plt). For Charts, additional available data types are comma separated z values (.csv), and (X,Y,Z)-points (.csv).

When the data is exported using the function “Export” >> “Current document as...”, every Chart in the measurement document is stored in the export file consecutively. In the binary format, the blocks of data from each Chart are stored directly one behind the other. In the “ASCII” text format the blocks of data for each Chart are separated by two empty lines.

Tagged image file format (.tif), portable network graphics (.png), and Windows bitmap (.bmp)
All of these image file formats are suitable for inclusion in electronic documents, e.g. of word- or image-processing software. The exact image as seen on the computer screen will be saved in the file ("screen shot").

Data file 16Bit (.dat)

A binary data file can be processed in image processing software. This "binary" data format contains only the measured data. The data is stored consecutively line by line upwards as 16-bit values (–32768 to +32767). The data is first processed using the settings chosen in the Data filter setting of the Chart bar.

Plotfile ASCII (.plt)
This is an "ASCII" text format which contains the measured data as well as a small header with a description of the scan. The data is stored using the setting "Data filter" in the "Chart bar". A measurement as a plotfile can be used for detailed data analysis by various mathematical software packages such as MathLab or plotted by GnuPlot.

If "Line graph" is selected as "Display" in the "Chart bar", only the visualized lines will be stored. Each data point is stored as a pair of floating point numbers on a separate line. The number pairs are separated by a blank character (SPACE).

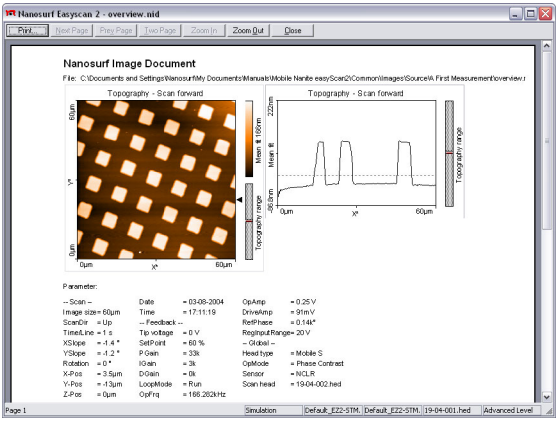
If any other chart type is selected, all measured values are stored. All values in a data line are stored on a separate line in the text file. An empty line is inserted after every data line. The data lines are stored from the bottom to the top. A small header at the beginning of the first data line contains the names of the channel and frame, as well as X-, Y-, and Z-ranges with their physical units.

Comma separated z values (.csv)
This format stores all the measured data in a chart, as a matrix of floating point numbers in ASCII format separated by a "comma" and "SPACE" character. This enables easy data exchange with commonly used spread sheet and database applications.

(X, Y, Z)-Points (.csv)
This format stores the coordinates of all measured points in a chart as a list of floating point number pairs. For Line graphs, only X and Z points are exported.

Print, Print preview...

Prints the currently selected measurement document together with the values shown in the Data Info panel.



20.2: Creating a report

The Nanosurf Report software package offers a powerful and extensive set of analysis functions. Complex analyses can be created interactively, and then displayed and printed in visually appealing reports. These reports can then be used as templates to apply the same analysis to another measurement.

The Report software is started from the easyScan 2 software by either clicking  , or using the Report menu. When a measurement is opened by the report software, it will import all measurement channels that are displayed in the current measurement document.

IMPORTANT

- After a fresh installation of the Report software, the Report software has to have run at least one time before you can automatically start it from the easyScan 2 software. To run the Report software for the first time, select it from the MS Windows “Start” menu.

IMPORTANT

- If you do not save the measurement in the easyScan 2 software, but only save the report, the data in measurement channels that were not displayed is lost.
- A measurement document should only display those channels that are used in a template. When a template is applied to a measurement document that displays different, or a different number of measurement channels than the template uses, the results may not be correct.

The Report generator configuration dialog is used to configure the behavior of the Navigator Icon and the Report menu. For an in depth introduction to the Nanosurf Report software, refer to the Introduction section of the Nanosurf Report online help.

20.2.1: The Report Menu

New Report

An empty report is opened.

Add Measurement

The currently active measurement is added to the currently opened report.

Apply Template...

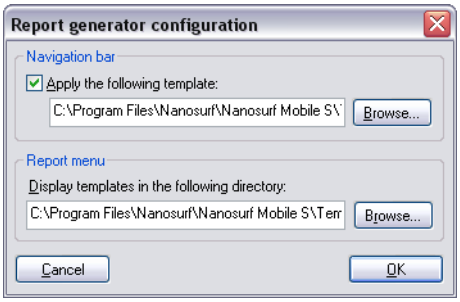
Opens a dialog that allows you to select a template that is applied to the currently active measurement.

Template list

The template list is a list of the templates that are stored in the template directory (see *Section 20.2.2: The Report Generator Configuration dialog*). Selecting a template applies this template to the currently active measurement.

20.2.2: The Report Generator Configuration dialog

The Report generator configuration dialog is used to configure the behavior of the Navigator Icon and the Report menu. It is opened using the menu “Options” >> “Config Report...”.



Navigation bar

Determines what happens when the  icon is clicked. The check box determines whether the active measurement is evaluated using a template. The “Browse...” button is used to select the template that is used when the icon is clicked.

Report menu

Determines which templates are displayed in the lower part of the Report menu. The “Browse...” button allows the selection of the directory where the templates are stored.

CHAPTER 21:

Automating measurement tasks

CHAPTER 21: Automating measurement tasks

The easyScan 2 Scripting Interface is an optional component for automating measurement tasks. It offers several possibilities to automate measurement tasks:

- Create scripts inside the easyScan 2 software.
- Create external software that controls the easyScan 2 software.

This chapter describes the user interface features that are related to creating scripts inside the easyScan 2 software.

After purchasing it, the Scripting Interface must be activated using the Edit Access Codes dialog (section *Section 13.7: The Edit Access Codes dialog* (page 139), or follow the instructions on the Access code certificate delivered with the instrument.)

For more information about the automating measurement tasks, and the available script commands, refer to the *Programmers Manual*. This manual is available as an online help file, that can be opened via the Windows Start menu: "Start" >> "Program Files" >> "Nanosurf" >> "Nanosurf easyScan 2" >> "easyScan 2 Programmers Manual".

21.1: The Script Menu

The scripting functions of the easyScan 2 software are reached via entries in the Script menu:

Script Editor...

Opens the Script Editor dialog.

Run From File...

On selecting this menu entry, a file dialog appears that allows selecting a script file by browsing. When the script is error free, the script will start executing on clicking the "Load" button. Otherwise, and error message with an error description will appear.

Other entries

All scripts in the “Scripts” directory (located in the easyScan 2 Software installation directory) are displayed alphabetically below the Run From File menu entry. Selecting one of these entries starts the corresponding script. Scripts can be organized in subdirectories inside the “Scripts” directory, which are displayed as submenus in the software. These submenus are displayed before individual scripts in the Script menu.

21.2: The Script Editor

The easyScan 2 software has an simple integrated Script Editor that allows editing, running, loading and saving scripts. The can be used in parallel with other application windows, so you can work with other parts of the application while editing a script. The Script Editor is accessed via the menu “Script” >> “Script Editor...”.

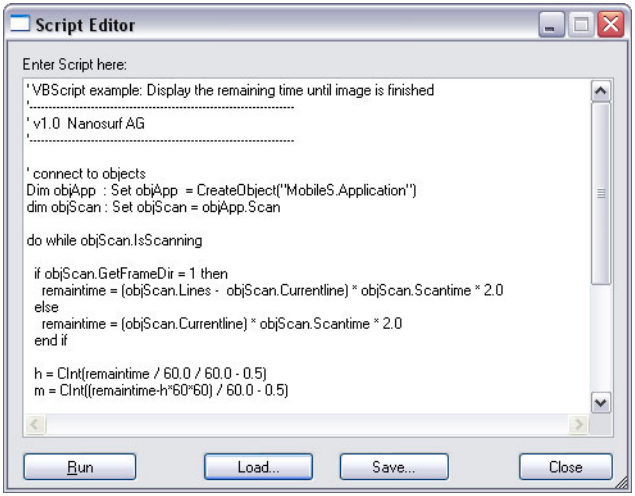


Figure 21-1: The script editor

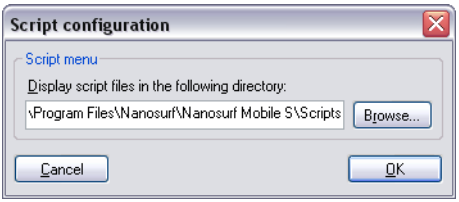
Editor field

In the editor field in the center of the dialog you can edit scripts.

Run Button
Starts the currently loaded script. If there is an error in the script, a dialog box will appear.

21.3: The Script Configuration Dialog

The Script Configuration Dialog allows you to set the search path for the scripts that are displayed in the Script menu. The dialog is accessed via the menu entry "Options" >> "Config script...".



Quick reference

Quick reference

Control Panels

Approach 142
Data Info 193
Imaging 151
Lithography 176
Operating Mode 114
Spectroscopy 160
Tool Results 196
Video 145
Z-Controller 125

Dialogs

About 140
Cantilever Browser 128
Chart Properties 190
Color Palette 192
Controller Configuration 136
Edit Access Codes 139
Layer Editor 178
Object Editor 181
Pixel Graphic Import 173
Report Generator Configuration ... 216
Scan Axis Correction 135
Scan Head Calibration 133
Scan Head Selector 132
Script Configuration 220
Script Editor 219
Signal Module Configuration 137
User Interface 110
User Signal Editor 117
Vector Graphic Import 171
Vibr. Freq. Search Parameters 124
Vibration Freq. Determination 121

Menu items

File
- Chart Arrangement 187
- Close ..... -
- Export 212
- Open 212
- Parameters 110
- Print 214
- Print preview... 214
- Print Setup ..... -
- Save 212
- Save as... 212
- Workspace 108

Options
- Config Access Codes... 139
- Config Cantilever Types 129
- Config Color Palette 192
- Config Controller 136
- Config Report 216
- Config Scan Head 132
- Config script 220
- Config User Interface 110
- Simulate Microscope 139

Report
- Add Measurement 215
- Apply Template... 215
- New Report 215

Script
- Run From File 218
- Script Editor 218

Tools
Calculate Area Roughness 205
Calculate Line Roughness 204
Correct Background 206
Correct scan line levels 207
Create Cross Section 202
Cut Out Area 203
Glitch Filter 207
Measure Angle 201
Measure Distance 200
Measure Length 199
Noise Filter 209
Window..... -

Operating windows

Imaging 148
Lithography 166
Positioning 142
Report 214
Spectroscopy 158